DIMENSIONS NBS

The magazine of the
National Bureau
of Standards
U.S. Department
of Commerce
June 1978

CORROSION. See page 12.

COMMENT

INDUSTRY, INNOVATION, AND NBS

There is a growing concern over the decline in innovative research and development by American industry. The number of patents granted U.S. citizens declined 21 percent between 1971 and 1976. During the same period, patents to foreign residents grew 16 percent. By 1976, 37 percent of all United States patents were going to foreigners. Our share of world manufacturing exports simultaneously has been shrinking, with noticeable effect on our balance of trade. Some countries now appear to be beating us at our own game: developing and exporting innovative technology.

Recognizing the importance of science and technology to our economy, President Carter recently asked me to chair an interagency committee to review issues and problems related to industrial innovation. Our committee* will examine the impact on innovation of Federal economic policy, regulatory policy, and foreign relations, and report our findings within 14 months. We hope to develop a number of options that address ways in which the government can help industry strengthen its research efforts.

In the meantime, we are taking a number of related actions at the Commerce Department. For example, Jordan J. Baruch, our Assistant Secretary for Science and Technology, has been investigating the role of "cooperative technology" programs in advancing critically needed technologies common to firms in selected industry groups.

We have within Commerce an organization that has long been engaged in cooperative efforts with industry—as well as with universities, other Federal agencies, state and local governments, foreign countries, and the public. This agency is the National Bureau of Standards.

Seventy-seven years ago, NBS was established to ". . . serve any firm, corporation, or individual within the United States engaged in manufacturing, or other pursuits requiring the use of standards or standard measuring instruments."

Since that time, American industry has become one of the biggest users of NBS science and technology. A major reason for this is the Bureau's commitment to do things that industrial and commercial firms cannot do for themselves. Often the scientific or technical skills involved are beyond the capabilities of private laboratories. In other cases, the reasearch involved is too expensive for any one company to undertake, and anti-trust laws prevent cooperative ventures among several companies.

Through its Research Associate Program, for example, NBS has brought scientists from industry to work at NBS on problems of mutual interest. But this is only one of the many ways in which NBS works with industry. The Bureau's recent reorganization, described in this issue of DIMENSIONS, will further strengthen its cooperative role with industry.

Juanita M. Kreps

Juanita M. Kreps
Secretary of Commerce
Room 5851
U.S. Department of Commerce
Washington, D.C. 20230
202/377-2112

* Other members of the interagency committee are the White House Science Adviser; the Secretaries of the Department of Energy, Defense, Health, Education, and Welfare, and Treasury; the Attorney General; the administrators of the Environmental Protection Agency and the National Aeronautics and Space Administration; the directors of the National Science Foundation and the Office of Management and Budget; the Chairman of the Council of Economic Advisers; the Assistant to the President for National Security Affairs; and the Special Representative for Trade Negotiations.

DIMENSIONS NBS

The magazine of the
National Bureau of Standards
U.S. Department of Commerce
Volume 62/Number 6
June 1978

Contents

ARTICLES

2 **Reorganization: A New Look for NBS**
New Organization Reflects Director's Desire to Increase Effectiveness

12 **The Economic Effects of Corrosion**
Study Shows Annual Cost of Metallic Corrosion to U.S. Economy is $70 Billion

18 **Metric vs. Customary: Which Is More Accurate?**
A Look at How Each System Sometimes Appears More Accurate

INTERFACE

20 **ON LINE WITH INDUSTRY**
NBS, ASM Join to Improve Phase Alloy Information

21 **STANDARD STATUS**
NBS Investigates Graphite as Future Standard Reference Material

22 **STAFF REPORTS**
The NBS Computer Network Measurement System
Advances in Understanding of Laser Spectra of Symmetric Molecules
New NBS Standards Aid Measurement of Fuel Economy
New Thermal Expansion SRM Available

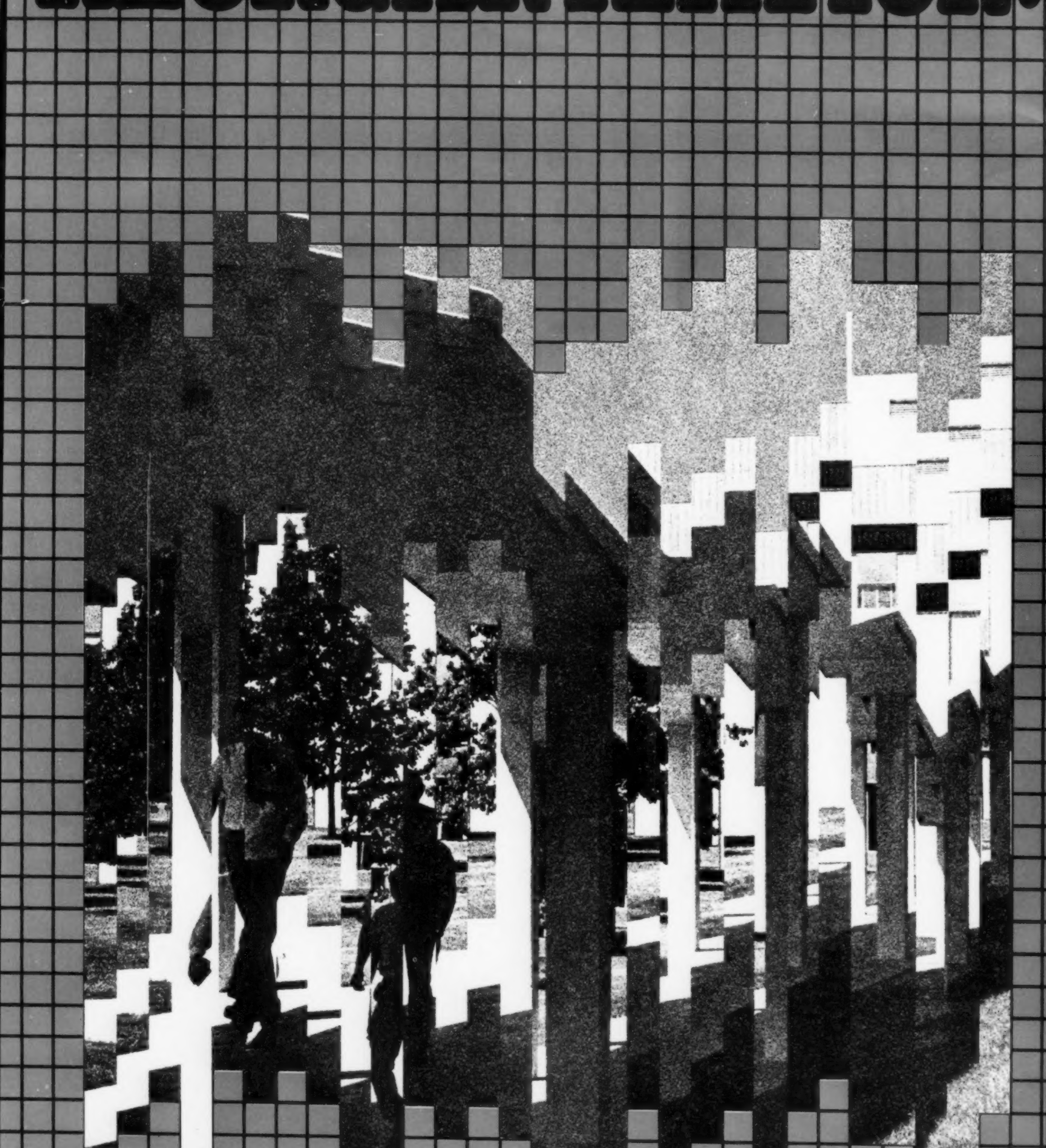
UPDATE

28 **CONFERENCES**
Crystal Growth Conference
NCSL and Regulatory Impact on Metrology Management Symposium
Building Regulatory Research—Innovation Conference
Conference Calendar

30 **PUBLICATIONS**
Buildings Damaged in 1977 Romanian Earthquake
Teacher Aids
Publication Listing

32 **NEWS BRIEFS**

REORGANIZATION:



A New Look for NBS

by Madeleine Jacobs

THE first major reorganization of the National Bureau of Standards in more than a decade has just been completed. Unlike many changes within organizations, the Bureau's new structure will affect not only the internal machinery, but also the communities with which NBS interacts and the clients it serves.

"The driving force behind the reorganization was my desire to increase the Bureau's effectiveness, and I believe quite strongly that the new structure will do just that," says NBS Director Ernest Ambler, who initiated and coordinated the change. He cites three major benefits: The Bureau is now organized along functional lines; technical competences that had grown up over the years in various organizational units have been consolidated; and the number of formal organizational units has been reduced.

The new Bureau is a streamlined version of its former self. Basically, three of the major technical operating units—the Institute for Materials Research (IMR), the Institute for Basic Standards (IBS), and the Institute for Applied Technology (IAT), have been abolished and two laboratories established. They are the National Measurement Laboratory, headed by Dr. John D. Hoffman, former director of IMR, and the National Engineering Laboratory, under the direction of Dr. John W. Lyons, former director of IAT and previously director of the Center for Fire Research.

To Ambler, this structure is a reflection of the dual role that NBS has had since its birth 77 years ago. "There is our classic mission as a central reference laboratory for all kinds of measurements in engineering, physics, and chemistry. Our other mission has been to apply this basic competence to solve problems.

"The two roles are complementary. The competences required to operate a successful reference laboratory can be drawn on to solve more specific technical problems. On the other hand, by working on such problems, we maintain the contact with many important areas that stimulate the work of the reference laboratory. The establishment of the National Measurement Laboratory and the National Engineering Laboratory means that we are now organized to serve these dual roles better."

Jacobs heads the NBS Media Liaison and General Publications Groups in the Public Information Division.

Ambler

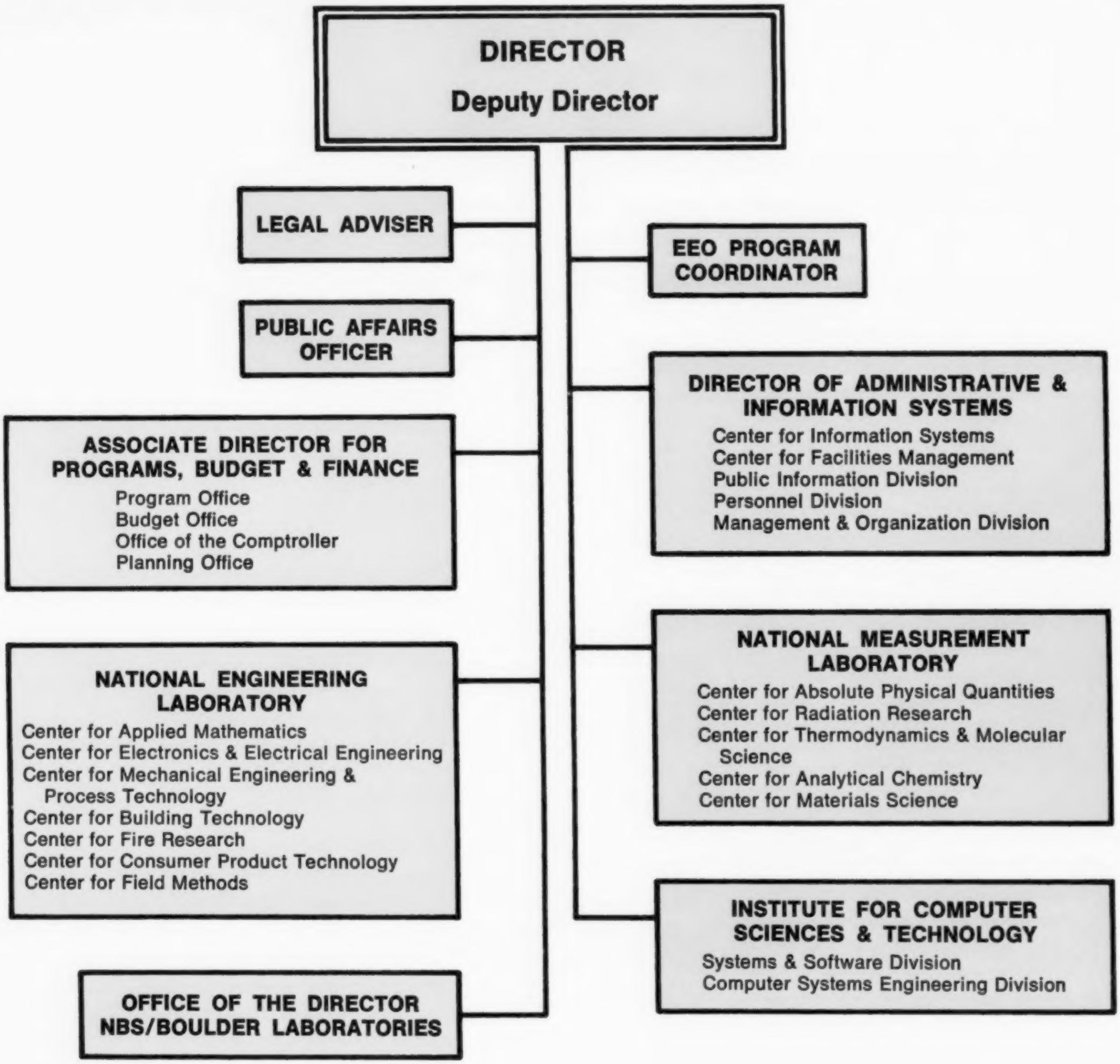
Central Reference Laboratory

NML is made up primarily of technical units from IMR and IBS. It has five centers organized along disciplinary lines and a number of offices that direct the scientific programs by drawing on the competences in the centers and divisions (see organizational chart). The centers cover absolute physical quantities, radiation research, thermodynamic and molecular science, analytical chemistry, and materials science.

According to Hoffman, "The National Measurement Laboratory is a reference laboratory that will provide the national system of physical, chemical, and materials measurement. As a reference laboratory, it is our role to tie together systems of measurement to assure that results of measurements made anywhere in the United States refer to the same bases or anchor points. NML will also coordinate the overall U.S. measurement system with those of other nations, paving the way for the free flow of information and goods."

Hoffman says the reorganization provides an opportunity to highlight areas of current and future scientific interests. He points to new divisions that were formed, such as thermophysics, molecular spectroscopy, surface sciences, chemical stability and corrosion, and fracture and deformation. "The reorganization also provides an opportunity for some of our bright young scientists to show what they can do as technical managers."

turn page


DIRECTOR
Deputy Director
LEGAL ADVISER
PUBLIC AFFAIRS OFFICER
ASSOCIATE DIRECTOR FOR PROGRAMS, BUDGET & FINANCE
Program Office
Budget Office
Office of the Comptroller
Planning Office
NATIONAL ENGINEERING LABORATORY
Center for Applied Mathematics
Center for Electronics & Electrical Engineering
Center for Mechanical Engineering & Process Technology
Center for Building Technology
Center for Fire Research
Center for Consumer Product Technology
Center for Field Methods
OFFICE OF THE DIRECTOR NBS/BOULDER LABORATORIES
EEO PROGRAM COORDINATOR
DIRECTOR OF ADMINISTRATIVE & INFORMATION SYSTEMS
Center for Information Systems
Center for Facilities Management
Public Information Division
Personnel Division
Management & Organization Division
NATIONAL MEASUREMENT LABORATORY
Center for Absolute Physical Quantities
Center for Radiation Research
Center for Thermodynamics & Molecular Science
Center for Analytical Chemistry
Center for Materials Science
INSTITUTE FOR COMPUTER SCIENCES & TECHNOLOGY
Systems & Software Division
Computer Systems Engineering Division

Hoffman

Lyons

Thornton

With regard to building for future scientific work, he says, "Standards work is exacting and demanding. The acceptance of our standards depends on people being able to rely upon our results. To do a thorough job, our work must be done by a highly competent scientific and technical staff. This means that we need the type of scientists who understand not only the techniques for careful measurement but also the underlying concepts of what is being measured and possible sources of error. It takes a long time to develop such scientists. I consider the strengthening and maintenance of a strong scientific foundation as one of my most important aims in making NML responsive to the nation's needs."

Engineering Laboratory

The National Engineering Laboratory is made up of seven centers drawing on most of the units formerly located in IAT plus substantial parts of IBS (see organizational chart.) NEL's centers are applied mathematics, electronics and electrical engineering. mechanical engineering and process technology, building technology, fire research, consumer product technology, and field methods (including the Experimental Technology Incentives Program). NEL will also have two offices, one for energy conservation programs and one for engineering standards. Within this structure, NEL will apply technology to the solution of a broad range of national problems.

"NEL is unique in its breadth of interests, its charter to serve many clients, its concern for engineering measurements and standards, and its ability to mount a variety of programs addressing national problems," Lyons says. "We are now assessing the technical capabilities which are essential to the centers and which need to be strengthened. These competences represent the NEL scientific foundation on which effective problem solving activities are based. I take it as axiomatic that one cannot do good problem solving without good science."

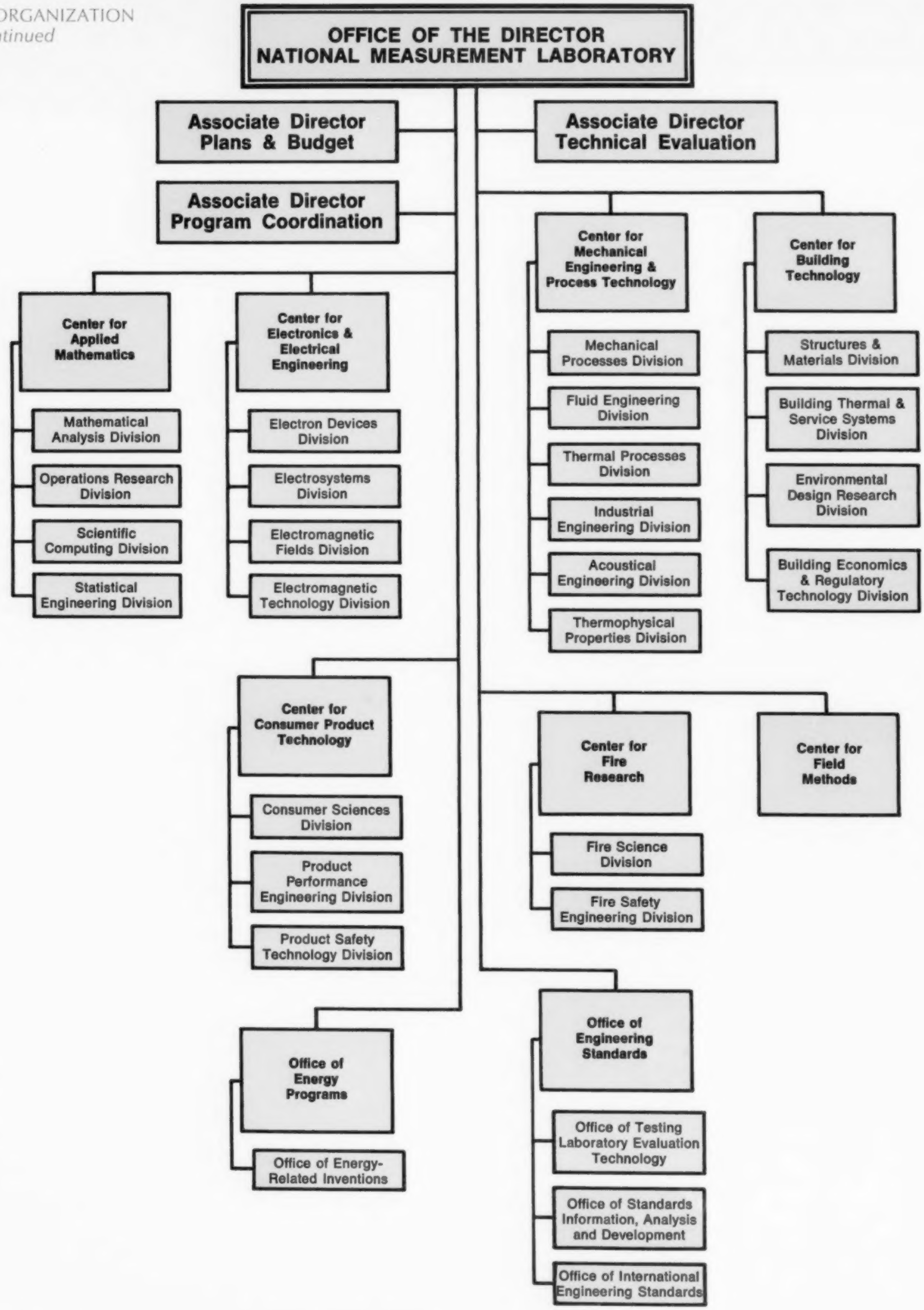
Lyons says that his goal for NEL is "to be a preeminent focus of engineering science expertise in those areas in which we work. I would like people to say of us that we can do first rate scientific work in an area and at the same time come up with an effective solution to a pressing national problem."

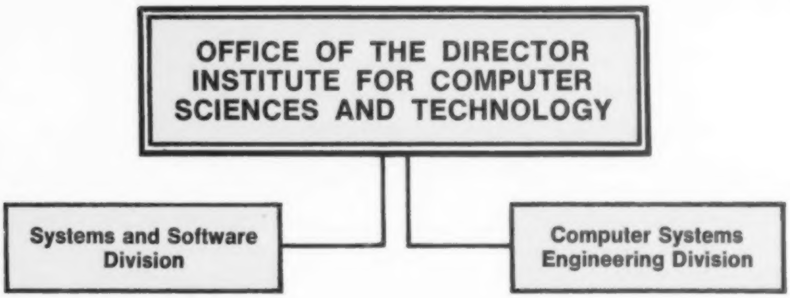
Another new organizational unit at NBS is the Office of the Director/Boulder Laboratories. Prior to the reorganization, the NBS Boulder Laboratories in Colorado were part of the Institute for Basic Standards. Three divisions in Boulder now report to centers within NEL and two report to a center within NML. "The new structure will provide more program coherence," says Bascom Birmingham, director of the Boulder Laboratories. "The concept of shared authorities, in which I will work with the directors of NML and NEL on technical programs, is an exciting and challenging one."

Computer Science Programs

Although the reorganization primarily affected IAT, IBS, and IMR, the Institute for Computer Sciences and Technology (ICST) was also restructured. The Office of Developmental Automation and Control Technology was transferred to NEL and the Computer Services Division, which provided Bureau-wide computer needs, was transferred to a new administrative unit. Under the direction of acting director Zane Thornton, ICST will continue to carry out its mission established by the Brooks Act of 1965 (Public Law 89-306). ICST provides federal computer standards, guidelines, and scientific and technical advisory services aimed at helping achieve economy and effectiveness in the government acquisition, application, and use of computer technology.

turn page


OFFICE OF THE DIRECTOR NATIONAL MEASUREMENT LABORATORY
Associate Director Plans & Budget
Associate Director Technical Evaluation
Associate Director Program Coordination
Center for Applied Mathematics
Mathematical Analysis Division
Operations Research Division
Scientific Computing Division
Statistical Engineering Division
Center for Electronics & Electrical Engineering
Electron Devices Division
Electrosystems Division
Electromagnetic Fields Division
Electromagnetic Technology Division
Center for Mechanical Engineering & Process Technology
Mechanical Processes Division
Fluid Engineering Division
Thermal Processes Division
Industrial Engineering Division
Acoustical Engineering Division
Thermophysical Properties Division
Center for Building Technology
Structures & Materials Division
Building Thermal & Service Systems Division
Environmental Design Research Division
Building Economics & Regulatory Technology Division
Center for Consumer Product Technology
Consumer Sciences Division
Product Performance Engineering Division
Product Safety Technology Division
Center for Fire Research
Fire Science Division
Fire Safety Engineering Division
Center for Field Methods
Office of Energy Programs
Office of Energy-Related Inventions
Office of Engineering Standards
Office of Testing Laboratory Evaluation Technology
Office of Standards Information, Analysis and Development
Office of International Engineering Standards



"Our job is a big one," states Thornton, "because we are attempting to gain leverage on the world's largest user of automatic data processing resources. These resources cost the government over $10 billion annually and comprise more than 10 600 computers staffed with more than 150 000 technical personnel. The problem of bigness is compounded by the complexity and rapid change of computer technology. The reorganization will create and maintain the kind of climate that allows ICST to do its work in an effective and efficient way." To carry out these tasks, ICST has divisions concerned with systems and software and computer systems engineering.

Administration, Information

Two new organizational units at NBS are the Office of the Director of Administrative and Information Systems (ODAIS) and the Office of Programs, Budget, and Finance (OPBF). Headed by Richard Bartlett, ODAIS brings together central administrative and technical support functions. "In the administrative area, the reorganization has improved the type, level, and quality of administrative services that are provided to NBS as a whole," says Bartlett. By centralizing administrative functions to some extent in the laboratories and to a greater extent in ODAIS, the scientists and engineers will have more time to focus on their technical activities, he believes.

Similarly, a grouping together of related functions in OPBF means better coordination of Bureau programs, according to Raymond Kammer, who is acting director of the office. A central planning office has also been established to provide overall guidance for the direction of Bureau research as a whole.

Director's Office

Staff functions that will report directly to Ambler include the legal adviser, the congressional liaison officer, the associate director for international affairs, the coordinator of the equal employment opportunity program, and the public affairs officer. A new Programmatic Center for Cooperative Technology has also been proposed in the Office of the Director. If Congress approves the funding, the Center will provide a focus for assessing the feasibility, desirability, and methodology for furthering cooperation among industry, universities, and government in the promotion and application of technological innovation in U.S. industry.

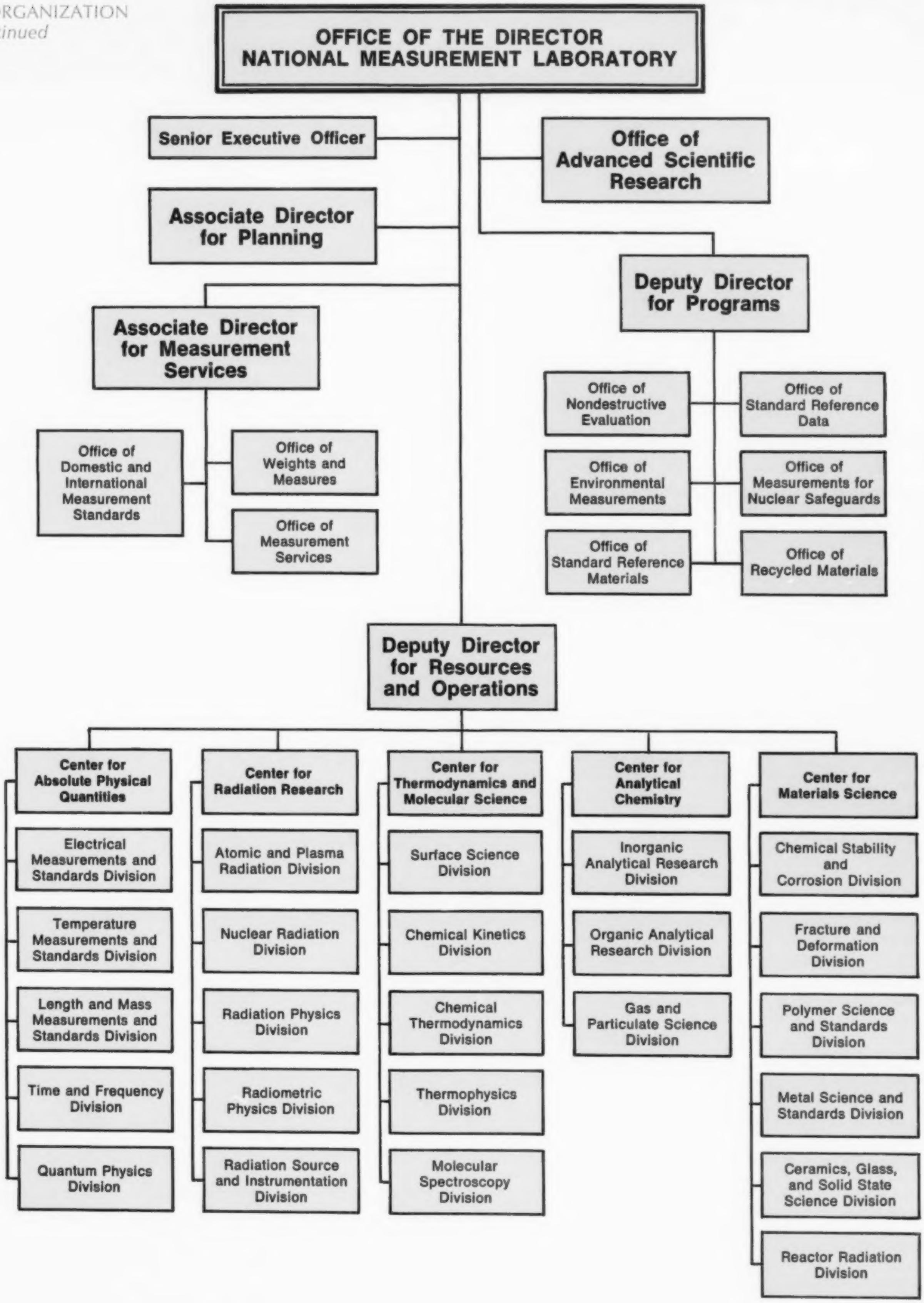
Outlook

As with most reorganizations, the benefits cited for the NBS change are higher efficiency, more flexibility, and fewer managers. According to Kammer, there is an important, although less tangible benefit from the Bureau's reorganization.

"NBS has been receiving a great deal of outside pressure, but that pressure has been impact-oriented. People on the outside are interested only in what is happening now. They don't stop to consider that it's also necessary to build for the future. The reorganization will provide a counterweight to that point of view. It will renew and reemphasize the commitment that NBS has to do long term work and conduct research that is not easily relatable to short term objectives."

Adds Director Ambler, "The bottom line on our performance rests largely on our level of scientific competence. Using that competence effectively is partially a function of our structure and I believe the new organization provides an efficient match between our capabilities and our responsibilities."

turn page


OFFICE OF THE DIRECTOR
NATIONAL MEASUREMENT LABORATORY
Senior Executive Officer
Office of Advanced Scientific Research
Associate Director for Planning
Deputy Director for Programs
Associate Director for Measurement Services
Office of Nondestructive Evaluation
Office of Standard Reference Data
Office of Domestic and International Measurement Standards
Office of Weights and Measures
Office of Environmental Measurements
Office of Measurements for Nuclear Safeguards
Office of Measurement Services
Office of Standard Reference Materials
Office of Recycled Materials
Deputy Director for Resources and Operations
Center for Absolute Physical Quantities
Electrical Measurements and Standards Division
Temperature Measurements and Standards Division
Length and Mass Measurements and Standards Division
Time and Frequency Division
Quantum Physics Division
Center for Radiation Research
Atomic and Plasma Radiation Division
Nuclear Radiation Division
Radiation Physics Division
Radiometric Physics Division
Radiation Source and Instrumentation Division
Center for Thermodynamics and Molecular Science
Surface Science Division
Chemical Kinetics Division
Chemical Thermodynamics Division
Thermophysics Division
Molecular Spectroscopy Division
Center for Analytical Chemistry
Inorganic Analytical Research Division
Organic Analytical Research Division
Gas and Particulate Science Division
Center for Materials Science
Chemical Stability and Corrosion Division
Fracture and Deformation Division
Polymer Science and Standards Division
Metal Science and Standards Division
Ceramics, Glass, and Solid State Science Division
Reactor Radiation Division

DIRECTORY*

NBS technical work is carried out in the National Measurement Laboratory, the National Engineering Laboratory, and the Institute for Computer Sciences and Technology. These groups are supported by the Office of the Director of Administrative and Information Systems; the Office of the Director, NBS/Boulder Laboratories; and the Office of the Associate Director for Programs, Budget, and Finance. This amalgam of people and programs forms a community dedicated to service. The interdisciplinary approach allows NBS to provide the Nation with scientific measurements of high precision and accuracy, coupled with actual solutions for current technology problems.

This directory provides a brief description, where appropriate, of the work of NBS major operating units. For more information on specific projects, contact the people listed. To reach members of the Gaithersburg, Maryland, staff, dial 301/921 + the extension listed, or write to the National Bureau of Standards, Washington, D.C. 20234. Bureau staff located in Boulder, Colorado can be contacted on 303/499-1000 + the extension listed, or at the National Bureau of Standards, Boulder, Colorado 80303. Boulder staff members are designated in the directory with asterisks.

For general inquiries on Bureau programs, dial 301/921-2318. Information on public affairs should be directed to R. S. Franzen, Public Affairs Officer, at 301/921-3112.

Office of the Director

Director	Dr. E. Ambler	2411
Deputy Director	Dr. T. A. Dillon	2451
Technology Adviser	Dr. H. E. Sorrows	2446
Associate Director for International Affairs	Dr. E. L. Brady /Act/	3641
Legal Adviser	Mr. A. J. Farrar	2425
Congressional Affairs Officer	Mrs. Esther C. Cassidy	2441

Office of the Associate Director for Programs, Budget, and Finance

Associate Director	Mr. R. G. Kammer /Act/	3130
Chief, Program Office	Mr. R. G. Kammer	3130
Chief, Budget Office	Mr. T. A. Gary	2544
Chief, Office of the Comptroller	Mr. L. D. Stout	2507
Chief, Planning Office	Mr. R. G. Kammer /Act/	3130

Office of the Director of Administrative and Information Systems

Director	Mr. R. P. Bartlett, Jr. /Act/	2477
Chief, Public Information Division	Mr. R. S. Franzen	3112
Chief, Personnel Division	Mr. M. Tammaru	3555
Chief, Management and Organization Division	Mr. R. A. Dixon /Act/	3581

Center for Information Systems

Director	Mr. J. T. Hall /Act/	3467
Chief, Computing Systems Design Division	Mr. E. I. Grunby	3710
Chief, Library Division	Mrs. P. W. Berger	3405
Chief, Office Management Division	Mr. R. de la Menardiere /Act/	2113
Chief, Technical Information and Publications Division	Mr. W. R. Tilley	2493
Chief, Computer Services Division	Mr. M. R. Shaver	3424

Center for Facilities Management

Director	Mr. K. E. Bell /Act/	3444
Chief, Plant Division	Mr. J. N. Brewer	2825
Chief, Instrument Shops Division	Mr. D. S. Bettwy	2436
Chief, Facilities Services Division	Mr. W. J. Rabbitt /Act/	2525
Chief, Occupational Health and Safety Division	Mr. L. E. Pevey /Act/	3366

Boulder Executive Office*

Executive Officer	Mr. A. R. Hauler	3955
Chief, Supply Services Division	Mr. J. S. Roettenbacher	3653
Chief, Instrument Shops Division	Mr. W. A. Wilson	3855
Chief, Plant Division	Vacant	3886

Office of the Director, NBS Boulder Laboratories

Director	Mr. B. W. Birmingham /Act/	3237*

National Measurement Laboratory

Director	Dr. J. D. Hoffman	2626
Deputy Director for Resources and Operations	Dr. E. Horowitz	2878
Associate Director for Planning	Dr. D. T. Goldman /Act/	3304
Deputy Director for Programs	Dr. D. R. Johnson	2822
Chief, Office of Nondestructive Evaluation	Mr. H. Berger	3331
Chief, Office of Environmental Measurements	Dr. C. C. Gravatt /Act/	3775
Chief, Office of Standard Reference Materials	Mr. J. P. Cali	3479
Chief, Office of Standard Reference Data	Dr. D. R. Lide, Jr.	2467
Chief, Office of Measurements for Nuclear Safeguards	Dr. H. T. Yolken	3868
Chief, Office of Recycled Materials	Dr. D. R. Johnson /Act/	2822
Associate Director for Measurement Services	Dr. A. O. McCoubrey /Act/	3301
Chief, Office of Weights and Measures	Mr. A. D. Tholen /Act/	2401
Chief, Office of Measurement Services	Dr. B. C. Belanger	2805
Chief, Office of Domestic and International Measurement Standards	Mr. D. E. Edgerly	3662

Center for Absolute Physical Quantities

Director	Dr. K. G. Kessler	2001
Deputy Director	Dr. R. P. Hudson	2034
Chief, Electrical Measurements and Standards Division	Dr. B. N. Taylor	2701
Chief, Temperature Measurements and Standards Division	Dr. J. F. Schooley	2801
Chief, Length and Mass Measurements and Standards Division	Dr. R. P. Hudson /Act/	2034
Chief, Time and Frequency Division	Dr. J. A. Barnes	3294*
Chief, Quantum Physics Division	Dr. G. H. Dunn	3527*

Center for Radiation Research

Director	Dr. J. E. Leiss	2551
Deputy Director	Dr. J. S. O'Connell /Act/	2551
Chief, Atomic and Plasma Radiation Division	Dr. W. L. Wiese /Act/	2071
Chief, Nuclear Radiation Division	Dr. R. S. Caswell /Act/	2625
Chief, Radiation Physics Division	Dr. C. E. Kuyatt	2051
Chief, Radiometric Physics Division	Dr. J. L. Tech	3864
Chief, Radiation Source and Instrumentation Division	Dr. S. Penner /Act/	2654

**As of June 15, 1978*

turn page

continued

Center for Thermodynamics and Molecular Science

Director	Dr. M. D. Scheer	2711
Deputy Director	Dr. W. H. Kirchhoff	2711
Chief, Surface Science Division	Dr. C. J. Powell	2161
Chief, Chemical Kinetics Division	Dr. W. Tsang	2792
Chief, Chemical Thermodynamics Division	Dr. D. Garvin	2131
Chief, Thermophysics Division	Dr. H. J. Raveché	2443
Chief, Molecular Spectroscopy Division	Dr. M. M. Hessel	2021

Center for Analytical Chemistry

Director	Dr. P. D. LaFleur	2851
Deputy Director	Dr. C. W. Reimann	2852
Chief, Inorganic Analytical Research Division	Dr. I. L. Barnes	2078
Chief, Organic Analytical Research Division	Dr. H. S. Hertz	3778
Chief, Gas and Particulate Science Division	Dr. J. K. Taylor	2886

Center for Materials Science

Director	Dr. J. B. Wachtman, Jr.	2891
Deputy Director	Dr. E. Passaglia /Act/	2893
Chief, Chemical Stability and Corrosion Division	Dr. T. D. Coyle	2847
Chief, Fracture and Deformation Division	Dr. S. M. Wiederhorn	2904
Chief, Polymer Science and Standards Division	Dr. R. K. Eby	3734
Chief, Metal Science and Standards Division	Dr. A. W. Ruff, Jr. /Act/	2811
Chief, Ceramics, Glass, and Solid State Science Division	Dr. H. P. R. Frederikse	2845
Chief, Reactor Radiation Division	Dr. R. S. Carter	2421

Institute for Computer Sciences and Technology

Director	Mr. M. Z. Thornton /Act/	3151

Systems and Software Division

Chief	Mr. S. Jeffrey	3531

Computer Systems Engineering Division

Chief	Mr. T. N. Pyke, Jr.	3436

National Engineering Laboratory

Director	Dr. J. W. Lyons	3434
Deputy Director	Dr. J. R. Wright	3574
Associate Director for Program Coordination	Mr. S. Kramer /Act/	3231
Associate Director for Plans and Budget	Vacant	3235
Associate Director for Technical Evaluation	Dr. G. A. Sinnott /Act/	3235

Center for Applied Mathematics

Director	Dr. B. H. Colvin	2541
Deputy Director	Dr. J. R. Rosenblatt /Act/	2315
Chief, Mathematical Analysis Division	Dr. F. C. Johnson /Act/	2631
Chief, Operations Research Division	Dr. A. J. Goldman	3855
Chief, Scientific Computing Division	Dr. B. H. Colvin /Act/	2541
Chief, Statistical Engineering Division	Dr. H. H. Ku /Act/	2315

Center for Electronics and Electrical Engineering

Director	Mr. J. C. French	3357
Deputy Director	Dr. A. H. Sher /Act/	3357
Chief, Electron Devices Division	Dr. W. M. Bullis	3786
Chief, Electrosystems Division	Dr. O. Petersons /Act/	3121
Chief, Electromagnetic Fields Division	Dr. H. S. Boyne	3131*
Chief, Electromagnetic Technology Division	Dr. R. A. Kamper /Act/	3535*

Center for Mechanical Engineering and Process Technology

Director	Dr. J. A. Simpson	3421
Deputy Director	Dr. J. M. Evans	3421
Chief, Mechanical Processes Division	Dr. R. D. Young /Act/	2181
Chief, Fluid Engineering Division	Dr. G. E. Mattingly	3681
Chief, Thermal Processes Division	Dr. K. G. Kreider /Act/	3281
Chief, Industrial Engineering Division	Vacant	—
Chief, Acoustical Engineering Division	Dr. D. S. Pallett	3381
Chief, Thermophysical Properties Division	Dr. R. H. Kropschot	4108*

Center for Building Technology

Director	Dr. R. N. Wright	3377
Deputy Director	Mr. H. E. Thompson	3375
Chief, Structures and Materials Division	Dr. E. O. Pfrang	2196
Chief, Building Thermal and Service Systems Division	Dr. P. E. McNall	3637
Chief, Environmental Design Research Division	Dr. F. T. Ventre	3704
Chief, Building Economics and Regulatory Technology Division	Mr. J. G. Gross	3447

Center for Fire Research

Director	Dr. F. B. Clarke /Act/	3143
Deputy Director	Dr. F. B. Clarke	3143
Chief, Fire Science Division	Dr. R. L. Levine	3845
Chief, Fire Safety Engineering Division	Mr. I. A. Benjamin	3255

Center for Consumer Product Technology

Director	Dr. S. I. Warshaw	3751
Deputy Director	Mr. J. L. Donaldson /Act/	3751
Chief, Consumer Sciences Division	Dr. H. P. Van Cott	2907
Chief, Product Performance Engineering Division	Dr. A. J. Fowell	3748
Chief, Product Safety Technology Division	Mr. W. G. Leight	3750

Center for Field Methods

Director	Mr. R. T. Penn /Act/	3185

Office of Engineering Standards

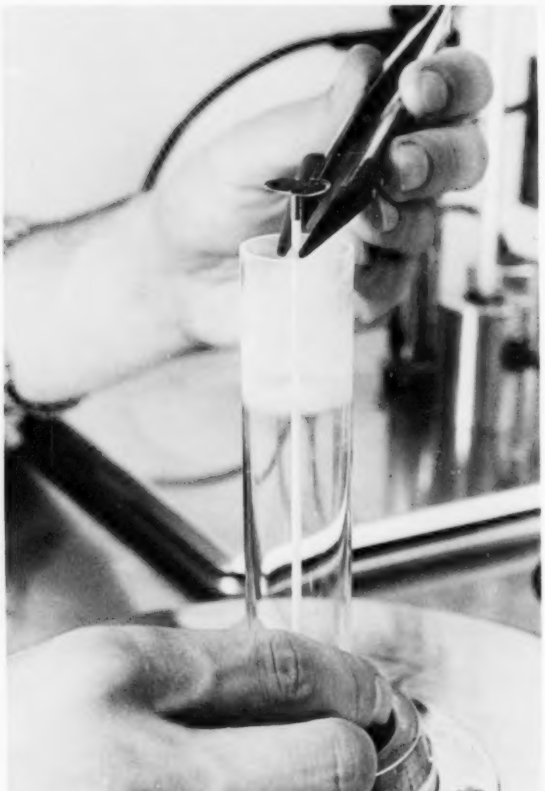
Director	Mr. G. A. Rowland	2128
Deputy Director	Mr. W. C. Cullen	3731
Chief, Office of Standards Information, Analysis, and Development	Dr. L. D. Eicher	2092
Chief, Office of Testing Laboratory Evaluation Technology	Dr. N. F. Somes	2368
Chief, Office of International Engineering Standards	Mr. W. E. Andrus, Jr.	3662

Office of Energy Programs

Director	Dr. J. E. Snell	3275
Chief, Office of Energy-Related Inventions	Mr. G. P. Lewett	3694

The Economic Effects of CORROSION

COVER STORY



A shallow platinum cup holds a sample of metal in this analysis instrument which will heat it to temperatures as high as 1700 °C in a closed environment to study the chemical reactions between the sample and its environment as the metal corrodes.

by Michael Baum

SUPPOSE you had an unlimited supply of U.S. \$1000 bank notes. Suppose you started stacking them until eventually you had a neat pile of \$1000 notes somewhat over 7600 meters high—slightly under half a kilometer shorter than Mount Annapurna in the Himalayas. What would that represent?

It would represent a reasonable estimate of the annual cost of metallic corrosion to the U.S. economy: \$70 billion.

That—less the visual imagery—was the conclusion of a study recently completed by the National Bureau of Standards on the economic effects of corrosion. In other terms, metallic corrosion cost the country about 4.2 percent of the gross national product for the study year 1975.

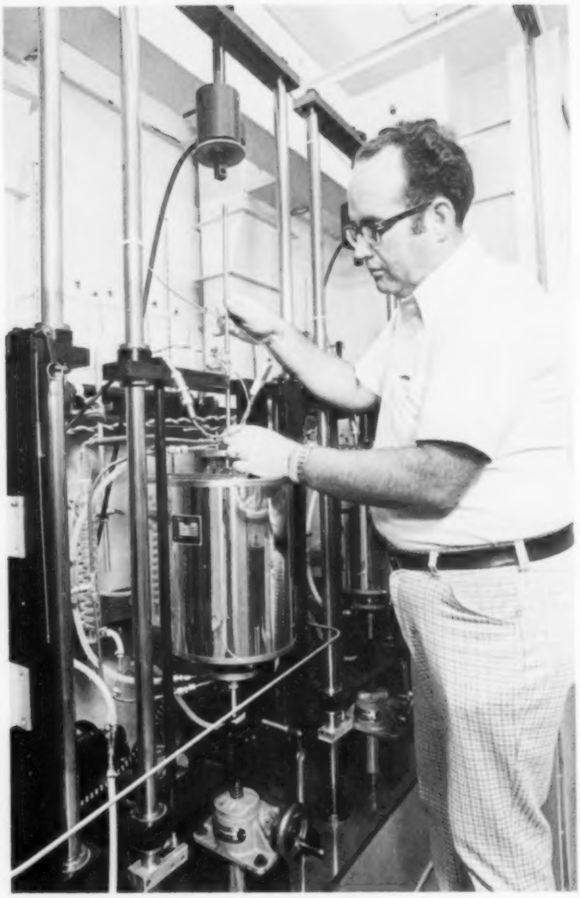
Here are a few other significant findings:

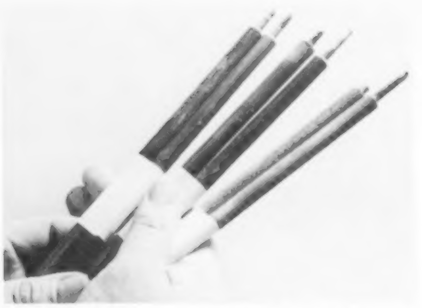
- About 15 percent of the corrosion cost—in the neighborhood of \$10 billion—could probably be avoided by making the best possible use of available technology.
- The cost of corrosion to the federal government is about 2 percent of the federal budget—in 1975, around \$8 billion.
- Metallic corrosion costs automobile owners in this country between 6 and 14 billion dollars per year, of which \$2 billion or more could be avoided by the economical use of anti-corrosion measures and improved maintenance.

Corrosion Consciousness

Any homeowner is aware that metallic corrosion—the gradual degradation and breakdown of metal under the attack of air, water, chemical products, and pollutants—is an annoying and costly fact of life. Just how costly, however, has been a matter of some uncertainty.

Baum is a writer and public information specialist in the NBS Public Information Division.





Developing energy technologies such as coal gasification will subject materials to severely corrosive environments. The broken steel rods above were placed under tension and heated to over 550 °C in corrosive atmospheres to test their resistance to the corrosive. Technician Christian Johnson (left) places a sample rod in a test chamber.

Using the equipment and techniques of a biologist, Warren Iverson (below) studies how microbial activity contributes to corrosion, a question of particular interest to the owners of oil field machinery and pipelines.

The complete price tag covers not only the replacement of parts that become corroded, but also treatments (such as painting) to prevent corrosion, use of expensive materials to resist corrosion, and the time and labor associated with these measures. When corrosion requires that a plant shut down for maintenance, there are subtle costs associated with the procedure that are difficult to assess, such as those that result from interrupted supply. Time and money spent on corrosion research must also be included.

Then too, there is a substantial price to pay when corrosion is a factor in the premature replacement of an entire product as opposed to a part (an automobile, for example), and when, as with Air Force planes, the size of an inventory must be increased to offset corrosion losses. Probably the most subtle costs accrue from the irreplaceable fuel and metal resources that are "wasted" in combatting and compensating for corrosion.

Over the years, several attempts have been made both here and abroad to determine the total cost of corrosion, with varying degrees of success and accuracy. Typical figures include an estimate from West Germany that its corrosion price tag in 1969 was about 3 percent of the gross national product, and a USSR estimate, also for 1969, that sets its cost at about 2 percent of the GNP.

One of the best documented of the recent studies was conducted in the United Kingdom for the 1969-70 period. Based on confidential information and interviews with representatives of 800 British industries and all government departments, the Minister of Technology arrived at a cost that was equal to 3.5 percent of the GNP for that period, and an estimate that 23 percent of that figure was potentially avoidable.

The study greatly added to the "corrosion consciousness" in Britain. Resulting efforts included the establishment of the National Corrosion Service with an information "hot line" for industries with corrosion problems, and a Corrosion and Protection Centre for Industrial Services to act as a central supplemental agency for corrosion research.

Previous American studies have been more incomplete. A 1940's estimate set the yearly direct expense of corrosion in the U.S. at 5.5 billion dollars and a study by the National Association of Corrosion Engineers estimated the direct corrosion costs to NACE members alone at $9.67 billion for 1975.

In 1975, the U.S. Congress directed NBS to undertake a study of the costs of corrosion. NBS was chosen because of its expertise in materials and corrosion research.

turn page

Above left. *This photomicrograph shows the effect of intergranular corrosion in a high strength aluminum alloy, a major problem in the use of these alloys in the aerospace industry.* Right. *The cost of corrosion to the fabrication of structural metal in 1975 is estimated to be over two and a half billion dollars.*

Corrosion Price Tag

The new NBS report, entitled *Economic Effects of Metallic Corrosion in the United States,* is the first comprehensive study of corrosion costs to use a sound economic method, a model that incorporates all the cost elements and allows the researchers to estimate the error in their figures. NBS was aided in the application of the economic model by Battelle Columbus Laboratories. (see box). As a result, the NBS figures are both more reliable and significantly higher than any previous study for the U.S.

Researchers not only figured the overall cost of corrosion to the U.S. economy, but also the cost to individual sectors of the economy; estimates of how much expense could be avoided using present knowledge; and estimates of the amount of error involved in the figures.

Out of the $70 billion corrosion expense, for example, somewhere between 10 and 45 percent is believed to be "avoidable." The error for the total figure is estimated to be about 30 percent either way. In other words, the total is probably more than 50 billion dollars and less than 90 billion dollars.

In the NBS study, "avoidable cost" was the money that could be saved by making the best possible use of existing corrosion control measures. This does not mean using the best possible way to prevent corrosion (conceivably, making farm tractor parts of platinum would be an effective anticorrosion measure), but rather it refers to the most cost-effective combination of materials selection, design, preventive maintenance, and replacement.

"The major finding of this report is that corrosion costs our economy a lot more money than previous estimates would lead us to believe," says Lawrence Bennett, who served as the NBS project chief. "This is something that a lot of people have suspected. What we've done is to put that belief on a firm basis. This was an attempt to provide a more thorough and accurate study of the expense of corrosion than has ever been done before, but it's a first attempt, not a perfect report."

Rust and the Family Car

The NBS researchers conducted a number of in-depth studies on several sectors in the economy. One area that received close attention was personal automobiles. Probably every automobile owner in the country is aware that there are some very real costs associated with corrosion. But accurately estimating just what they are proves to be very difficult, according to the NBS researchers.

The reason? Corrosion costs for automobiles fall into one of three categories: money paid for built in protection, such as heavier, more expensive metals, special designs, or special coatings; maintenance and operating costs, such as the replacement of mufflers, tailpipes, and radiators, or painting; and the cost of premature replacement—the loss incurred by selling a car early at a reduced value and buying another because of corrosion damage. Of these three factors, the most important and the most difficult to estimate is that last—premature replacement.

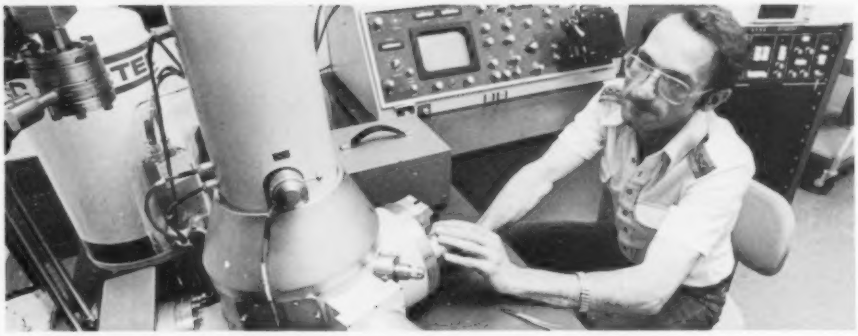
"Corrosion is a factor in the lifetime of a car," explains Bennett. "What it means is this: Say you get into an accident or have engine problems and it's going to cost $300-$400 to repair. Obviously the extent of corrosion damage to the car will be a factor in whether you sell it or repair it. In very few cases will you be able to say that the car is junked only because of corrosion, but certainly this is a *factor* in shortening its life."

Recognizing that the estimation of a car's life-time includes several uncertainties, the researchers placed the annual cost of corrosion to the nation's car owners at somewhere between 6 and 14 billion dollars. Of that, they estimated, about 2 to 8 billion could be saved through the use of anti-corrosion techniques and improved maintenance by the owner.

Although not every sector of the economy received the close attention that personal automobiles did, the researchers conducted similar in-depth studies of the effects of corrosion on the federal government, on the electric power industry, and on energy and materials resources.

Of the estimated $8 billion cost to the federal government from corrosion, the study revealed that about $2 billion went for maintenance. The balance represents increased inventories or decreased product lifetimes. The researchers calculate that the best use of current anti-corrosion techniques could save about 20 percent of that $8 billion.

turn page



Chemist Taki Negas studies a sample of corroded metal with a scanning electron microscope to determine the microchemistry of the corrosion process.

PERSPECTIVES ON CORROSION

GOVERNMENT

"Combining the expenses for aircraft, ship and real property leads to an annual maintenance corrosion cost estimate of $1.775 billion on 84 percent of all Federally owned capital. Based on that, a total cost of corrosion maintenance in the Federal sector is estimated to be about $2 billion annually."

INDUSTRY

"Maintenance expenditures in the electric power industry due to corrosion are estimated to be about 10 percent of all maintenance costs in the areas of transmission, distribution, and miscellaneous and about 50 percent of all maintenance costs in the area of generation of power."

AUTOMOBILES

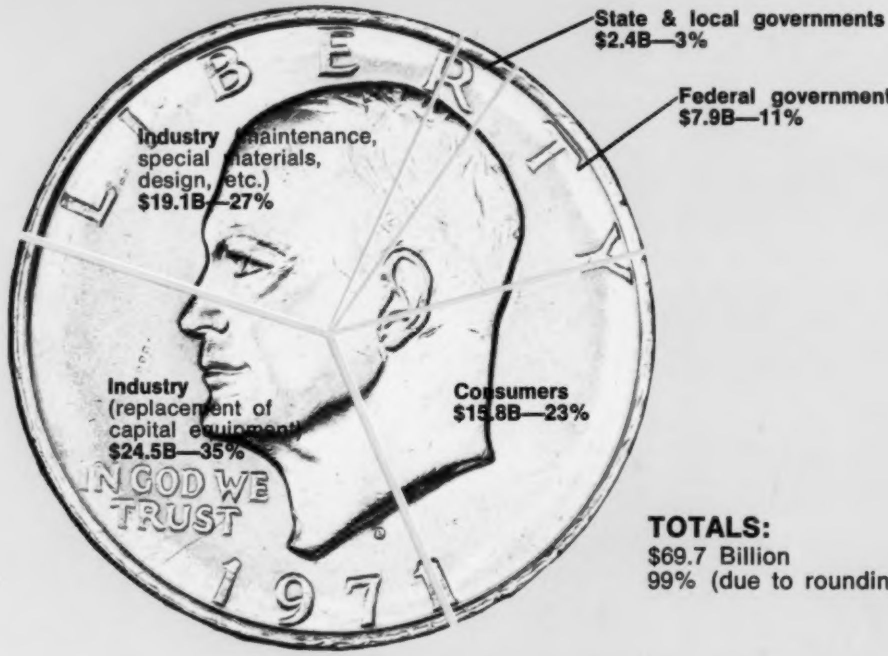
"The principal expenses of corrosion in the ownership of an automobile are associated with the degradation of components made of the iron and steel which comprise approximately 80 percent of the weight of an auto. These costs may be separated into three parts:

- Costs of built-in protection against corrosion included in the purchase price.
- Those portions of maintenance and operating costs attributable to corrosion.
- Costs of premature replacement of autos."

CORROSION: WHERE DO THE DOLLARS GO?

TOTAL ANNUAL COST

(by economic sector)



TOTALS:
$69.7 Billion
99% (due to rounding)

These two graphs show how the cost of corrosion are distributed throughout the American economy. Of the total cost of corrosion (estimated at close to $70 billion in 1975), industry incurred approximately 62 percent: 27 percent for maintenance, special materials and design, increased inventory, and the like and 35 percent to replace plant equipment or "fixed capital."

Together these are the extra costs incurred by industry in carrying out its business. These costs are eventually passed on to the final consumer of the outputs of industry. The segments showing costs to consumers and governments include the cost of maintenance and the premature replacement of equipment.

The graph below shows how the corrosion costs that are considered to be "avoidable" are distributed. These are estimated to be about 15 percent of the total corrosion cost—about $10.7 billion in 1975

TOTAL AVOIDABLE COST

(about 15% of total cost)

TOTALS:
$10.7 Billion
100%

Where the Numbers Came From

How do you estimate the economics of something as widespread as corrosion? The National Bureau of Standards study was based on a special computer model used by Battelle Columbus Laboratories, a research organization skilled in both corrosion control and economic analysis. In a cooperative research effort, Battelle supplied the computer model system, NBS performed the final summary and error analysis, and combined research teams from both organizations produced the actual numbers and estimates needed for the model.

The Battelle model is a modified version of an economics technique known as input/output analysis. Developed by Harvard economist and Nobel Laureate Wassily Leontief in the late 1940's, input/output (I/O) analysis provides a quantitative method for dealing with comparatively fine details of an economic system by breaking down the flow of monies and materials into individual "sectors" of the economy, such as metal manufacturing, government, households, petroleum products, and so on.

Each sector is considered as both producer and consumer, and the resulting model can be manipulated mathematically to show how changes to one or more sectors affect the rest of the model.

For the corrosion analysis, Battelle developed three models or "worlds" to conform to various conditions. World I was essentially the economic system of the United States in 1975. World II was an idealized world in which no corrosion existed and related costs were therefore zero. World III was a world in which the most cost-effective corrosion control technology was used. The comparison between World I and World II gave the total cost of corrosion, and between World I and World III gave the total "avoidable" expense.

To develop the actual numbers for the economic model, NBS and Battelle researchers used available sources of information, including previous studies and extrapolations from previous studies, industry statistics and estimates, and numerous interviews with knowledgeable experts in each economic sector. The model itself incorporated some 130 such sectors. Further information on the Battelle I/O model may be obtained from Mr. John Mesaros, Room 10-158, Battelle Columbus Laboratories, 505 King Avenue, Columbus, OH 43201. For further information on NBS programs in the area of corrosion, contact Dr. Elio Passaglia, B312 Materials Building, National Bureau of Standards, Washington, D.C. 20234.

. . . about 50 percent of the money spent on maintenance of power generators is attributable to corrosion . . .

continued

Corrosion expenses in the electric power industry vary depending on the type of electrical generator used, but in general, the researchers found that about 50 percent of the money spent on maintenance of power generators is attributable to corrosion, a sum amounting to about $1.1 billion per year. The total direct corrosion costs for the industry are estimated at roughly $4.1 billion. Interestingly, the report concluded that the "best use" of corrosion control methods would not significantly affect the corrosion costs of the electric power industry, because this industry is one of those sectors that successfully applies the best currently available corrosion-prevention technology.

Estimating the longer range expense of corrosion —the depletion of energy and material resources— the study concluded that the country spends for corrosion about 3.4 percent of the total amount of energy it consumes, a relatively low amount compared to corrosion's other costs. Within the energy sectors, coal usage is the most affected by corrosion. About 18 percent of the energy loss is estimated to be "avoidable."

The effect of corrosion is more dramatic in the field of metallic ores, where it is thought to account for about 16.7 percent of the yearly consumption, about 2.1 percent of which is "avoidable."

Toward the Future

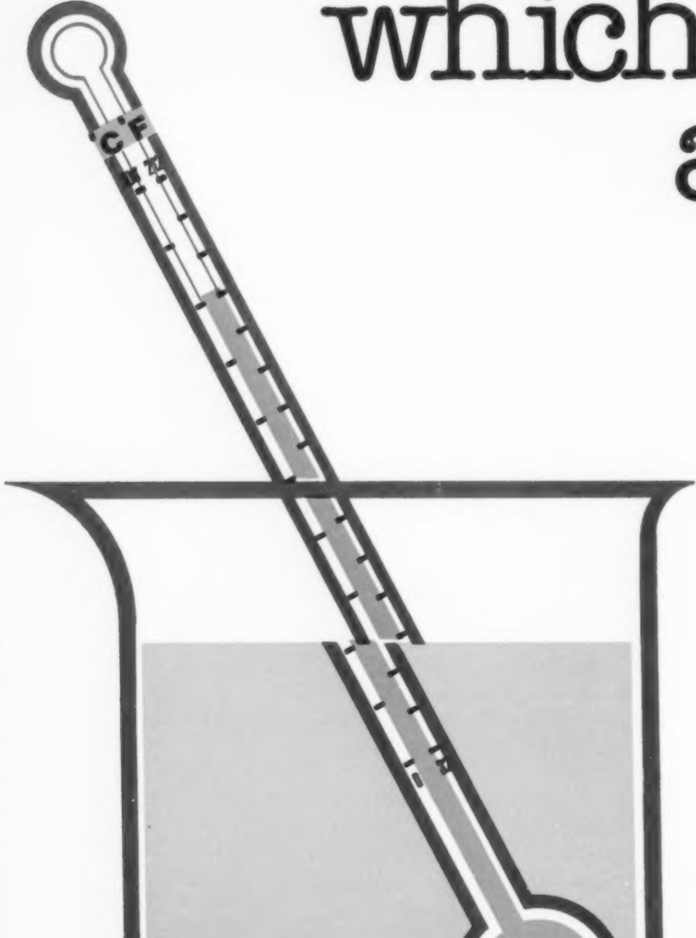
One factor left out of the NBS study—because it was impossible to estimate the economic effect—was the development of new techniques and technologies in the field of corrosion control. Corrosion costs in developing fields such as nuclear power and the offshore production of oil may be expected to rise in the future, according to the researchers, in the absence of new technologies to control them.

Many advances are being made in research organizations that will result in reducing corrosion costs. At the National Bureau of Standards, current research ranges from esoteric studies of the corrosive effect of hydrogen atoms on the lattice structure of metals to inquiries into methods of plating other metals on aluminum (a process that, if effective, will allow automobile manufacturers to substitute strong, lightweight aluminum alloys for steel, with a corresponding savings in gas consumption).

NBS projects address corrosion problems in existing technologies—one group is studying ways to inhibit corrosion in the steel pilings used to support offshore oil wells—and in currently developing technologies, such as the serious difficulties encountered in the development of magneto-hydrodynamics (MHD) electricity generators.

The ultimate goal of all this work? To lower that stack of banknotes by as many meters as possible. □

metric vs. customary: which is more accurate?



by Jeffrey V. Odom

AS the United States goes metric and American citizens become familiar with the new units, they are likely to encounter one or both of the following opinions:

1. Metric is more accurate than the conventional system of measurement.
2. Metric is not as accurate as the conventional system.

Obviously, both statements cannot be true, but before we try to cope with this contradiction, let's look at why one or the other can *appear* to be true:

—Metric units may seem more accurate because they have a more scientific basis than our customary "inch-pound" units. For example, a yard was intially defined as the length from the nose of King Henry I of England to the tip of his thumb. One inch equalled "three barley corns, round and dry, taken from the center of the ear, laid end-to-end." Such definitions imply a lack of uniformity. In contrast, the metric meter was initially defined as one ten-millionth of the quadrant of the earth. (A quadrant of the earth is the distance from the north pole to the equator). The centimeter is 1/100th part of the meter. Incidentally, that means that 100 centimeters make a meter, just like 100 cents make a dollar in our decimal currency. These relationships are orderly—and exact.

Odom is metric coordinator for the National Bureau of Standards.

—Another circumstance may make metric appear more accurate than our conventional system: When dual measurements are used, a metric equivalent is most commonly given for an even inch-pound size, and frequently the metric equivalent is expressed with more digits than necessary. For example, a label might read "3 quarts, 2.839 liters," giving the impression to some people that metric is more accurate, and also that metric is more complicated.

—Some people question the accuracy of the metric system on the following account: Units for the same quantity in the metric and inch-pound systems are not of the same *magnitude*. Current experience with metric weather forecasting has given some people the impression that temperatures expressed in degrees Celsius (°C), are less exact than when expressed in the more familiar degrees Fahrenheit (°F). This impression results from the fact that one degree Celsius is equal to 1.8 degrees Fahrenheit; a 5 °C interval is equal to a 9 °F interval. This means, in practice, that both 71 °F and 72 °F have a metric equivalent of 22 °C. In a similar manner, the equivalent metric body weight of both 121 pounds and 122 pounds is 55 kilograms.

With these examples in mind, let's go back to the original question, "Is metric more—or less—accurate?" and examine the facts.

First of all, the accuracy of a measurement system is *not* based on the standards or definitions for the units that make up that system. In fact, it is technically incorrect to speak of the accuracy of a measuring system. (One measuring system is as applicable as any other, so long as each is coherent.) It *is* proper to speak of the accuracy of any given measurement, or of the accuracy available from a measuring instrument. Thus, the metric system is not more accurate than our inch-pound system, regardless of how either evolved. Measurements with a meter stick and a yard stick can both have wide degrees of accuracy, depending only on how well the instruments are calibrated and used.

Secondly, conversions between any two systems can make the secondary system *appear* more accurate and more complicated. (Right now the secondary system is metric). Such conversions should be avoided, unless necessary for some special reason. When they occur (for example in the dual-dimensioning of products to aid shoppers in making comparisons between new metric sizes and similar items not yet changed), they reflect the fact that even sizes, such as one quart, are not so "even" when converted. Eventually, values such as 0.946 liter (or one quart) will be changed to "one liter" (or 1.057 quarts) and the present situation will be reversed.

Finally, it is true that the interval between successive numbers for some units, such as temperature (°C vs. °F) and weight (kg vs. lb) is larger in metric than in inch-pound units. Consequently, when temperature or weight is expressed in whole numbers, the metric value covers a wider range than the customary value. In everyday life, this difference is not important. For example, when planning what clothes to wear or deciding whether to go on a picnic, it really doesn't matter if it is 71 °F or 72° F. It is sufficient to know that it is 22 °C. We most certainly cannot tell the difference when we go outdoors between 71 °F and 72 °F, and probably not between 70 °F and 73 °F, either. Similarly, our body weights change slightly during the day, depending on our level of activity and the amount of food we eat, so it really doesn't matter that both 121 pounds and 122 pounds are reported as 55 kilograms. There are, of course, cases where temperatures or weights are needed within narrower ranges, as in laboratory experiments. With proper equipment, such measurements can be carried out easily and successfully. Temperatures can be measured to a thousandth of a degree Celsius, or less, if necessary. Similarly, weight can be determined within a very minute range.

Measurements with a meter stick and a yard stick can both have wide degrees of accuracy, depending only on how well the instruments are calibrated and used.

In short, there is no practical difference in the accuracy of the metric and the inch-pound systems. In either, you can measure with the amount of accuracy you need.

Also, it is important to stress, as we gradually move to the metric system, that we are not going metric because it is easier to use (although it is). Rather, we are going metric because it is used world wide. We truly have, with metric, an international measurement system. □

ON LINE WITH INDUSTRY

NBS, ASM JOIN TO IMPROVE PHASE ALLOY INFORMATION

by Michael Baum

A year ago last January, an international workshop was held at the National Bureau of Standards to consider a subject close to the heart of any industry working with metals—the phase diagram situation.

Phase diagrams are charts that show for a single metal or for a range of combinations of metals (alloys) the phases (liquid, solid, gas) that are present at different temperatures or pressures. They are used by engineers as guides in the selection, use, and processing of materials. Such diagrams, especially for multicomponent systems, are at times complex and difficult to determine.

They are also very important. In the smelting of ores and refining of metals, for example, accurate phase diagrams are needed to design processes that yield the maximum amount of usable metal with maximum efficiency. One industry representative at the 1977 workshop complained that phase information for copper slags is inadequate, that a single smelter could easily waste a million dollars a year in copper because of this deficiency, and that some discarded slags contain nearly as much copper as some ores.

Many metals industries, looking to improve their productivity, are eyeing new and innovative technologies in pyrometallurgical processes, noted another workshop participant, but the phase diagrams necessary to evaluate the new processes are not always available.

To help remedy such situations, the National Bureau of Standards and the American Society for Metals (ASM) have agreed to cooperate in establishing a phase diagram data program.

Under the terms of the Memorandum of Agreement signed last February, the program will supply phase diagram information and data on the constitution of alloys, establish a related bibliographic service and serve as a center to provide coordination with other groups compiling phase diagrams. ASM will develop the program, financially support the venture, and provide administrative services. NBS will provide technical guidance and assistance in developing and evaluating the phase diagram information.

The sheer range of applications for phase diagrams contributes to the difficulty of the task, according to the NBS Program Coordinator G. C. Carter. "The significance of the whole project is that it actually serves not just a large community but a large variety of communities, each with a different idea of what is most important in phase diagrams. You have the steel and copper industries, metal manufacturing as well as processing and refining, and in new areas of energy production you must deal with new materials that have to withstand very corrosive and adverse diagrams there. This program touches just about all the possible areas in materials research."

To help meet this demand, the NBS researchers plan to study ways to store the phase diagrams in computer data files from which they may be easily retrieved in formats tailored to individual applications. Similarly, there are plans to computerize the bibliographic files once they are established.

Another important problem, according to Carter, is the lack of available data on multicomponent systems — mixtures of three or more metals. As a member of the iron and steelmaking industry noted at last year's meeting, "We know quite a bit about a number of binaries (two-metal systems), but little about ternaries (three metals), and essentially nothing about quaternaries (four metals)."

One facet of the NBS/ASM program will be an attempt to alleviate this problem by working with a large variety of data sources. "Phase diagram data are being compiled considerably more in Europe than here," according to Carter, "and a major part of our program is to integrate what is going on elsewhere. So far we have found the members of this international group very anxious to cooperate in such a system."

The NBS/ASM program, formally the "Data Program for Phase Diagrams and the Constitution of Alloys," will be managed by an administrative office at Metals Park, Ohio in the headquarters of ASM. The results of the program will be published and distributed by ASM and by the National Standard Reference Data System at NBS.

The proceedings of the international workshop on "Applications of Phase Diagrams in Metallurgy and Ceramics," G. C. Carter, editor, NBS SP-496, are available from the Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20234. The two volumes of the proceedings total more than 1500 pages, and include more than 85 papers representing the major phase diagram research centers in the world. Order by Stock No. SN-003-003-01895-3, $15.25 per set.

For further information, contact:
L. H. Bennett, Rm B150 Materials Building, National Bureau of Standards, Washington, D.C. 20234.

Baum is a writer and public information specialist in the NBS Public Information Division.

NBS INVESTIGATES GRAPHITE AS FUTURE STANDARD REFERENCE MATERIAL

by Kent Higgins

Fine-grained isotropic graphite may provide an urgently needed Standard Reference Material (SRM) for thermal conductivity, according to researchers at the National Bureau of Standards.

Initial investigation of this graphite by the NBS Thermophysical Properties Division (formerly Cryogenics Division) and Office of Standard Reference Materials suggests that determination of thermal conductivity to within ±2 percent accuracy is possible with simple and inexpensive electrical resistivity and density measurements at room temperature.

Research is underway to confirm that this correlation is applicable over a wide temperature range. Other physical property characterization being considered by NBS include thermal diffusivity, specific heat, and thermal expansion. Chemical composition investigations are also under consideration.

The benefits of graphite as a Standard Reference Material include an applicable temperature range from 4 to 3000 K, relatively low cost, and convenient fabrication of the material.

SRM's are well characterized, stable, homogeneous materials produced in quantity and available from NBS. Each SRM is characterized with values for one or more physical and chemical properties, which are numerically expressed along with their associated uncertainties. SRM's serve as the anchor points for the calibration of many instrumental measurement systems.

NBS has obtained a supply of graphite rods (6.4, 12.7, and 25.4 mm diameter by 30 cm length) having a density range of 1.72 to 1.75 g/cm^3. This fine-grained graphite is fabricated from petroleum coke, with final graphitization performed at 2500 °C.

Electrical resistivity (4 to 300 K) and density measurements (20 °C) were performed on about 200 randomly selected rods. Thermal conductivity measurements were performed on 13 specimens at about 20 °C. Transport property variation, between and within the tested rods, was approximately ±10 percent. Since a correlation has been established between thermal conductivity, electrical resistivity, and density measurements, thermal conductivity values can be predicted for other specimens to an accuracy of ±2 percent at 20 °C.

At the culmination of the preliminary NBS thermal conductivity, electrical resistivity, and density measurements, select groups of specimens were prepared and distributed internationally to independent research and testing facilities. These laboratories are participating in a CODATA (Committee on Data for Science and Technology) program for standardization of thermophysical property measurements.

These facilities will measure several different transport properties over a wide temperature range on the NBS graphite material. Upon return to NBS, a post evaluation of the independently obtained data and the graphite specimens will be conducted to determine independent/NBS measurement and material property variations.

Completion of the independent characterization tests is expected by January 1979. Projected announcement of the availability of fine-grained homogeneous graphite SRM specimens is expected to occur during 1979.

Additional information may be obtained by contacting Jerry Hust, NBS Thermophysical Properties Division, Boulder, CO 80303, or the Office of Standard Reference Materials, National Bureau of Standards, Washington, D.C. 20234.

Higgins is a public information specialist in the NBS Program Information Office in Boulder, Colorado.

STAFF REPORTS

Computer Network, page 22
Symmetric Molecules, page 23
Fuel Economy, page 27
Thermal Expansion SRM, page 27

THE NBS COMPUTER NETWORK MEASUREMENT SYSTEM

NBS researchers have developed a Network Measurement System to help users evaluate the quality of computer services delivered through computer networks. This system measures the service delivered to the user rather than the internal operating efficiency of the system.

Marshall D. Abrams, Ira W. Cotton, Shirley Ward Watkins, Robert Rosenthal, and Don E. Rippy, Computer Systems Engineering Division, B212 Technology Building, 301/921-2601.

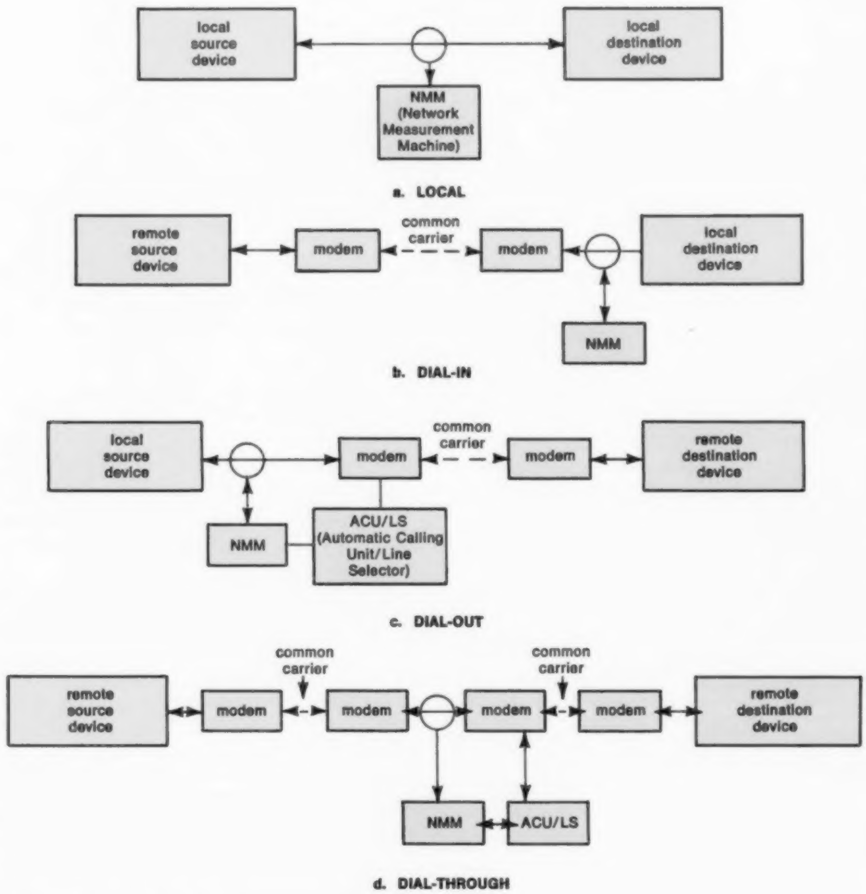


Figure 1—*Basic types of interconnections.*

More and more people are using interactive computer systems through terminals equipped with keyboard and printer or display. However, users lack sophisticated techniques for measuring and evaluating these systems other than the conventional performance measures of internal operating efficiency. Users, when they are selecting or improving network systems, are usually more concerned with the service that they receive than with the throughput of the entire system.

The Network Measurement System (NMS) consists of a data acquisition device called the Network Measurement Machine (NMM) and a Data Analysis Package (DAP) that provides information about the quality of network service delivered to interactive terminal users and about the character of user demand and network utilization.

Our system measures network performance in terms such as the following elements that can be readily quantified:

- Response time: the elapsed time from the last keystroke made by the user until the first printing character output by the system is displayed at the user's terminal.
- Interactive turnaround time: the elapsed time from the beginning to the end of a specified job or function.

The Network Measurement Machine (NMM) is implemented on a minicomputer employing regular and special purpose hardware controlled by a specially written software system. The regular hardware includes the processor, an operator's console, disk and magnetic tape storage, two programmable clocks, and data communications interfaces. Special purpose hardware is employed to connect the NMM to the network that is to be measured. This hardware includes an automatic calling unit and line selector for computer-controlled origination and answering of data calls, and a specially designed communications line interconnection device called a "data probe."

The special software system is a real-time interrupt-driven scheduler incorporating various drivers and handlers for the standard and special purpose peripherals attached to the NMM. A command interpreter serving the operator's console makes it possible to view the status of the NMM and to view the status of selected ongoing communication.

Data are not structured or analyzed during acquisition. Rather, all characters are time-tagged and written on magnetic tape with other pertinent information for subsequent analysis. Conversations from up to eight terminals operating in asynchronous mode can be acquired simultaneously.

Once recorded, the data are processed by the DAP. First, multiple conversations on the tape are separated into individual conversations. Each conversation is then processed to remove character echos (if appropriate), and scanned to build a structure file which contains pointers to the user and network messages. Different stratifications of the data (e.g., grouping by software processor employed by the user) can be noted in the structure file. Conversations may be analyzed individually or in aggregate, reports generated, and a file written for additional data processing by independent statistical packages including OMNITAB.

The NMS has potential application in the design, selection, procurement, and improvement of interactive computer networks and network services. These measurement techniques will enable users to specify the level of network service they want and to measure the service delivered. Both buyer and seller should benefit from having a straightforward way to determine whether contract terms are being met. Quantitative analysis of network service can help users of installed systems determine the level of service being provided, identify where improvements are needed, and evaluate the effects of changes made to the system.

The NMS may also be used to collect information about users and networks to help network designers and implementors identify potential areas for improvement. For example, the average transmission rate of users is a key factor in designing efficient multiplexing and concentrating communications networks. Similarly, knowledge of the relative utilization of various facilities by users can provide guidance as to where optimization efforts should be directed. Other areas of interest include the delays introduced by a data communications system and the overhead of communications protocols.

Several NBS Technical Notes and papers in technical publications have been written describing the organization, implementation, and applicability of the NMS. We have begun to use the Network Measurement System in a controlled and rigorous way. It has been employed in the selection of a computer system providing interactive remote access service and in an analysis of the interactive service demands and service quality on the NBS Univac 1108. Reports on both of these activities are in preparation.

ADVANCES IN UNDERSTANDING OF LASER SPECTRA OF SYMMETRIC MOLECULES

New ways to model rotational or rovibronic motions of spherical-top molecules greatly simplify the analysis of high resolution laser spectra and increase the understanding of molecular structure and dynamics. Such understanding is proving useful to researchers studying laser isotope separation, time and frequency standards, and laser-induced chemistry.

William G. Harter, Visiting Fellow, Joint Institute for Laboratory Astrophysics, Boulder, Colo. 80303, and Chris W. Patterson, Los Alamos Scientific Laboratory, Los Alamos, New Mexico 87545.

The need to understand extraordinary fine structure patterns in infrared absorption spectra of sulfur hexafluoride (SF_6), tetrafluoromethane (CF_4), and similar molecules has stimulated us to develop alternative techniques for calculating rovibrational energy of molecules excited to high values of angular momentum. The resulting new theory can replace tedious and expensive computer calculations with comparatively simple algebraic formulas. It also gives the spectroscopist a clear physical interpretation for details in the spectra.

Some examples of CF_4 spectra in figure 1 show the complexity of modern spectroscopy and put our analysis in context. The figure is to be viewed starting at the top (a) and then downward (b-e). Finer spectral details and higher resolution are envisioned at each of the lower stages of the figure. The first stage (figure 1-a) is a copy of the CF_4 vibrational structure which has been known for some time. A close look at one of these "lines" called (ν_4) is shown in the Fourier transform spectra figure 1-b by Alex Stein, Paul Rabinowitz, and Andrew Kaldor at Exxon Corporate Research Laboratory. The μ_4 detail clearly shows the rotational structure which consists of so-called "P","Q" and "R" branches of spectra. The P or R lines are numbered [. . . P(10) . . . P(20) . . .] starting at the central (Q) region. The number (N) in P(N) or R(N) stands for the total angular momentum of the CF_4 rotors.

The next stage (figure 1-c) shows the nature of fine structure of rotational lines by "zeroing in" on P(54). P(54) is one of the best available examples of laser diode spectra, and it was taken by Robin McDowell and coworkers at Los Alamos Scientific Laboratory (LASL). [Note that P(54) is virtually lost in the noise of the preceding figure 1-b.]

At first one might marvel at the complexity of the P(54) fine structure; however, it is actually much simpler than would have been expected. There are about 17 or so prominent lines in figure 2-c, yet it should be pointed out that an angular momentum (J=54) level has 109 sub-levels belonging to axial momentum components m=54, 53, 52, . . ., 0, . . ., −53, −54. By taking account of the tetrahedral symmetry of CF_4, one could prove that some of the (J=54) sub-levels merge with one another to make forty-six supposedly distinct lines. Besides "single" levels named "type A_1" and "type A_2" [(J=54) has five each of these], there are paired or doubly degenerated levels named "type E" [(J=54) has nine E's], as well as triply degenerate levels of "type F_1" and "type F_2" [(J=54) has 13 F_1's and 14 F_2's, which together with the A's and E's account for all 109 sub-levels grouped into 46 supposedly distinct lines]. Nevertheless, the number 46 is still nearly three times what we see in figure 1-c.

Now if one could look more closely at a P(54) spectrum most of the 46 A's, E's, and F's would be seen mysteriously "clustering" into orderly and repetitive patterns

turn page

Figure 1—*Spectra of tetrafluoromethane (CF_4).*

Figure 1 (a)—*CF_4 Vibrational Structure (Experiment: B. Monostori and A. Weber, J. Chem. Phys. 33, 1867 (1960), Raman spectra).*
Figure 1 (b)—*ν_4 Rotational Structure (Experiment: Alex Stein, Paul Rabinowitz, and Andrew Kaldor, Exxon Labs, (1977), Fourier Transform Infrared Spectra, 1.3 kPa, 10-cm path, 293 K).*

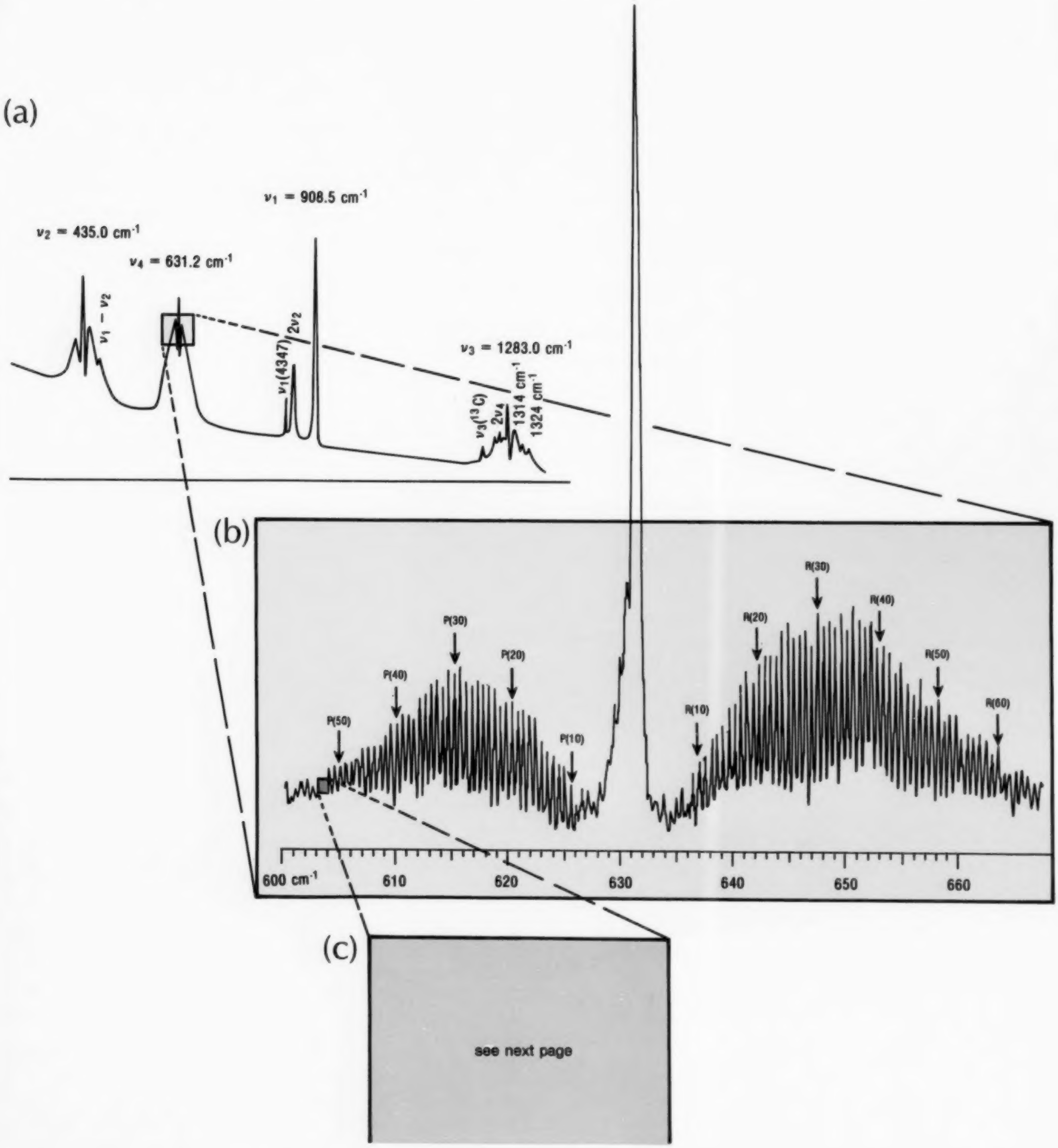


Figure 1 (c)—*P(54) Fine (Centrifugal) Structure (Experiment: R.S. McDowell, Los Alamos, (1977). Laser Diode Spectra, 280 Pa, 1-m path, 296 K).*
Figure 1 (d)—*Superfine ("Tumbling") Structure (Theory).*
Figure 1 (e)—*Hyperfine (Nuclear Spin) Structure.*

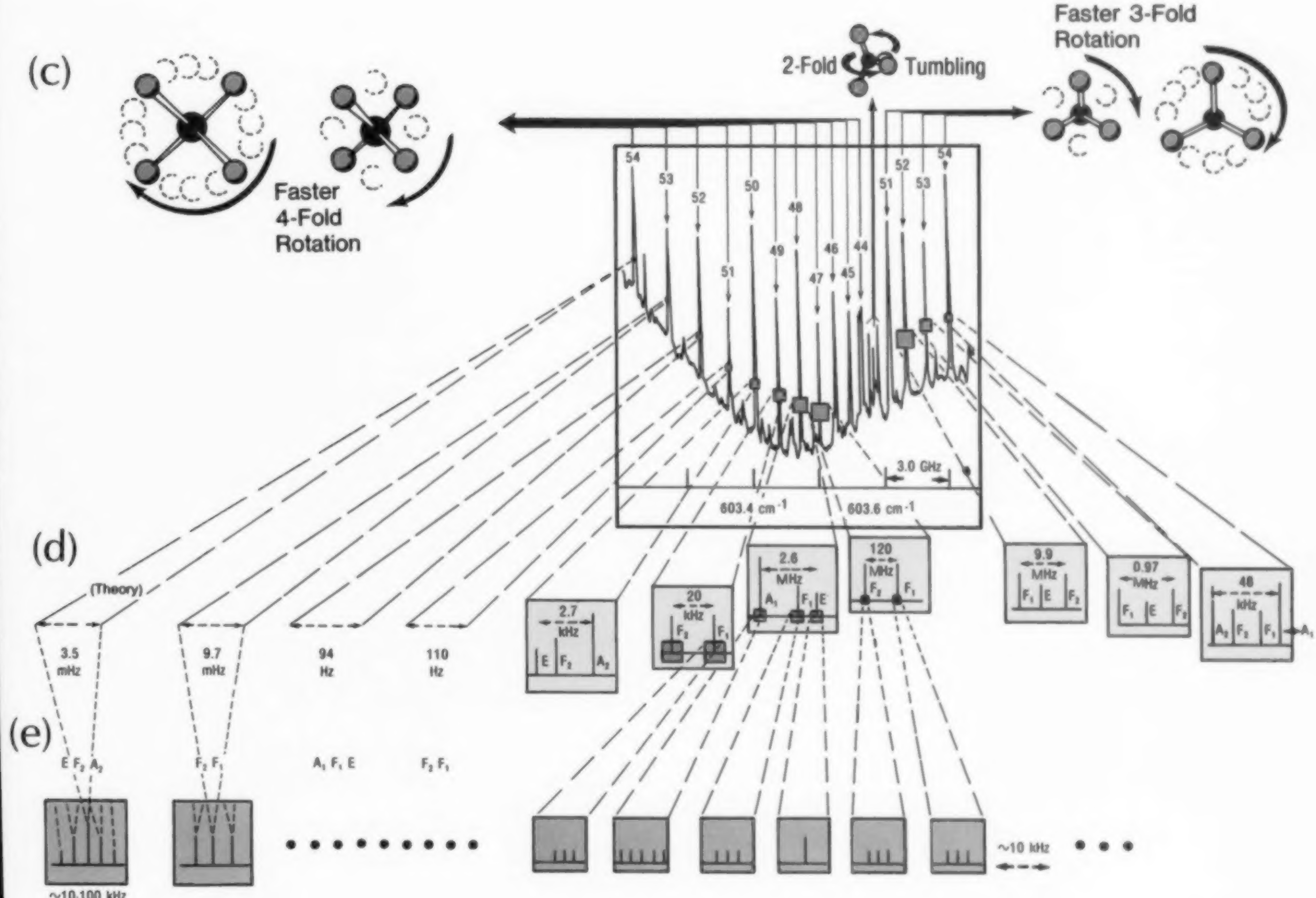
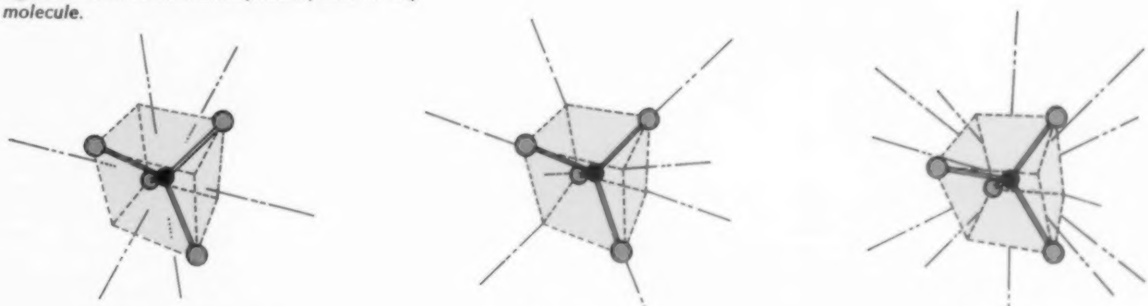


Figure 2—*Cubic-tetrahedral symmetry axes of CF_4 molecule.*



(a) Four-Fold Axes (b) Three-Fold Axes (c) Two-Fold Axes

turn page

of doublets ($F_1 + F_2$), triplets ($A_1 + F_1 + E$, $E + F_2 + A_2$, or $F_1 + E + F_2$), and quartets ($A_1 + F_1 + F_2 + A_2$) as shown in figure 1-d. "Closer looks" at SF_6 using Doppler-free saturation absorption spectra done by Moret-Bailley and coworkers at Dijon, France, has recently revealed this sort of "superfine" structure. Currently, Russell Peterson at NBS in Boulder is pursuing superfine studies for SiF_4, the "first cousin" of CF_4.

Our work at the Joint Institute for Laboratory Astrophysics (JILA) and Los Alamos has turned the clustering mystery into a simple and powerful analytical theory. This theory provides formulas for many different types of rovibronic fine structure, explains and predicts superfine structure or cluster splitting, and predicts further "hyperfine" structure (figure 1-e) yet to be seen. (John Hall at JILA has resolved a simple type of hyperfine structure in CH_4 and is currently studying future possibilities.)

To understand the basis of the theory, imagine dividing the CF_4 molecules into two major species: the "four-fold" species, and the "three-fold" species. The four-fold species spend most of their time rotating around any of six four-fold axes depicted in figure 2-a. The three-fold species do likewise on any of eight three-fold axes shown in figure 2-b. Because of CF_4 internal structure, four-fold species of a given momentum (J) are lower energy than the three-fold ones. Furthermore, the faster the four-fold species spin on their axes, the lower their energy, while faster spin means higher energy for the three-fold species.

Reading left to right in figure 1-c, there are four-fold P(54) clusters belonging to spin quanta 54, 53, 52 . . ., while the three-fold P(54) clusters start with the highest spin (54) on the right-hand (high energy) side. Note that ten four-fold superfine levels ($EF_2A_2F_2F_1A_1F_1EF_2F_1$) repeat after four clusters on the left-hand side of figure 1-d. A similar ordering of the same ten levels repeats after *three* clusters on the other side.

When a molecule is not spinning on a single internally fixed axis, we say it is "tumbling." With several axes to choose, a molecule spinning on one axis may tumble over to another axis, spin for a while, tumble again, spin, tumble, and so on. *The tumbling rate of a molecule associated with a given cluster is proportional to the superfine splitting of that cluster.* The tumbling frequencies or superfine splittings in P(54) are written in figure 1-d. [Tumbling frequency is analogous to tunneling frequency or inversion doublet splitting responsible for ammonia (NH_3) maser action; NH_3 doublet splitting equals the rate at which the N atom pops back and forth through the H_3 ring]. Note that clusters with higher spin are split less. This is because higher centrifugal distortion tends to "freeze" a molecule to a given axis, which discourages tumbling and reduces superfine splitting. The superfine splittings in figure 1-d are seen to vary in roughly decade steps over nearly twelve orders of magnitude! Superfine structure will provide a convenient testing ground for future spectral devices of *arbitrarily fine resolution.*

Note that the four-fold clusters have much smaller superfine splittings (cf. 3.5 mHz, 9.7 mHz, 9.4 Hz, . . .) than three-fold clusters of the same spin (cf. 48 kHz, 0.97 MHz, 9.9 MHz, . . .). This is because there are fewer four-fold than three-fold axes (compare figures 2-a and b) and more distance between to discourage tumbling and reduce superfine splitting.

Three- and four-fold superfine splittings in P(54) reach their maximum values on either side of 603.58 cm^{-1} in figure 1-c, where several unclustered levels are exposed. This small region belongs to rotations involving two-fold axes shown in figure 2-c and serves as a boundary between three- and four-fold clusters. Molecules put on two-fold rotation axes behave like divers doing "gainers," and they tumble as much as they spin. (To see how this tumbling looks, hold a tennis racket as you would a frying pan, and toss it end over end.)

Hyperfine structure in CF_4 (figure 1-e) is due to nuclear spin moments of spin-½ fluorine. Based on Pauli's famous exclusion principle, the hyperfine spin multiplets depend on the superfine levels A, E, or F, which in turn describe the permutational properties of the four fluorine nuclei. Such properties will be an important key to chemical dissociation or reactive collisions which may be studied and controlled by laser.

Finally, we note that an interesting relation between hyperfine and superfine structure emerges for the first time. Ordinarily, molecular hyperfine structure has been regarded as the finest structure available. Certainly, the hyperfine splittings in the center of figure 1-e are much smaller than the superfine splittings between A's, E's, and F's, which correspond to nuclear spin quintets, singlets, and triplets, respectively, according to conventional theory (see lower center of figure 1). However, superfine splittings of several millihertz (see left-hand side of figure 1-d) are tiny compared to the usual kilohertz hyperfine splittings. Then tumbling may occur only once every ten minutes, which is an eternity as far as the nuclear spins are concerned. Under these conditions the spins will "line up" with the internal molecular rotation axis and produce spectral patterns something like the NMR patterns which solid state physicists have seen (see lower left-hand side of figure 1-e). When this occurs, it will indicate that some of the usual rotational permutations have been "frozen out." Then the standard A, E, and F states have been merged into degenerate cluster states which will behave quite differently in physical and chemical processes.

Clearly the understanding of precision laser spectroscopy is one of the most promising doorways leading to sophisticated control of chemical energy in the future. Our developments show that this understanding may not be as hard to come by as we had thought.

NEW NBS STANDARDS AID MEASUREMENTS OF FUEL ECONOMY

New Standard Reference Materials that will promote more accurate measurement of fuel consumption of internal combustion engines are now available from the National Bureau of Standards.

New Standard Reference Materials (SRM's), Carbon Dioxide in Nitrogen (SRM 2619-2626), are intended for calibration of instruments that make high accuracy measurements of carbon dioxide, the major constituent of automobile exhaust. Fuel consumption is determined by chemical analysis of the exhaust products of an engine while the vehicle, mounted on a dynamometer, travels a measured distance in a prescribed driving schedule. The exhaust gases consist largely of carbon dioxide with only small amounts of carbon monoxide and unburned hydrocarbons. The overall accuracy of the measurements depends on the accuracy with which carbon dioxide can be measured.

This series of SRM's is designed for use by the Environmental Protection Agency (EPA) and by automobile manufacturers who determine fuel consumption by measuring exhaust products.

These SRM's will help enforce the new federal requirements for mileage that went into effect for the 1978 model automobiles. Derived from the Energy Policy and Conservation Act of 1975 (P.L. 94-163), these regulations were developed jointly by the Department of Transportation (DOT) and the EPA. The act specifies that the average fuel economy of passenger automobiles produced by each manufacturer in the 1978 model year is required to be no less than 18.0 miles per gallon (mpg).

Those manufacturers that do not comply with the average fleet mileage requirements will be fined $5.00 for every car sold for each tenth of an mpg that the average fuel economy falls short of the federal standards. Thus, if a manufacturer's average were 17.8 mpg in 1978 he would be fined $10 for every car sold. There are nearly 10 million cars sold every year and the potential cost of an error in computing the average fuel economy could be millions of dollars. If the calibrating gases used by industry are in error by one percent, the average fuel economy would also be in error by one percent and could lead to unnecessary fines or to undetected non-compliance. Thus, these new SRM's for carbon dioxide measurement are extremely important.

Other scientists who are required to make highly accurate carbon dioxide measurements may find these SRM's equally useful.

The gases are supplied in cylinders with a pressure of 12.4 MN/m^2 (1800 lb/in^2) and a delivered volume of 0.88 m^3 (31 ft^3) at standard temperature and pressure. Each cylinder of gas has been individually analyzed and the accuracy is certified to $\pm$ 0.1 percent.

The cost is $353 per cylinder, which includes the cost of the cylinder. Purchase orders for these SRM's should be sent to the Office of Standard Reference Materials, Chemistry Building, Room B311, National Bureau of Standards, Washington, D.C. 20234.

With these new SRM's, NBS now offers over 80 SRM's useful for environmental research and control.

NEW THERMAL EXPANSION SRM AVAILABLE

The NBS Office of Standard Reference Materials announces the availability of sapphire (Al_2O_3) as a Standard Reference Material for thermal expansion.

The thermal expansion of single crystal sapphire has been accurately determined over the temperature range 293 to 2000 K. It is the fifth in a series of eight thermal expansion reference materials. At 293 K the coefficient of expansion of this SRM is 5.4×10^{-6}/K while the coefficients of the other materials are: SRM 731, Borosilicate Glass, 4.8×10^{-6}/K; SRM 739, Fused Silica, 0.5×10^{-6}/K; SRM 736, Copper, 16.6×10^{-6}/K; and SRM 737, Tungsten, 4.4×10^{-6}/K.

Laboratories that measure thermal expansion have a definite need for reliable and accurate standards. Experience has shown that it is not uncommon for variations among laboratories using push-rod dilatometers and high temperature techniques to be of the order of a few hundred parts per million in $\Delta L/L$ measurements. Use of these SRM materials should significantly reduce these interlaboratory variations. Periodic use will also permit testing for variations in apparatus that may otherwise go unnoticed.

This single-crystal sapphire is the first thermal expansion SRM that can be heated above 1000 K in air and should be of particular interest to laboratories making high temperature measurements with alumina push-rod dilatometers.

SRM 732 is available in rod form 6.4 mm (¼ in) in diameter and 51 mm (2 in) in length. Orders for this material should be directed to the Office of Standard Reference Materials, Room B311, Chemistry Building, National Bureau of Standards, Washington, D.C. 20234. Longer multiple lengths may be obtained by special order. The price of SRM 732 is $179.

CONFERENCES

For general information on NBS conferences, contact Sara Torrence, NBS Office of Information Activities, Washington, D.C. 20234, 301/921-2721.

CRYSTAL GROWTH CONFERENCE

Electronic materials for industry and crystalline materials for energy applications are among the topics to be featured at the Fourth American Conference on Crystal Growth, July 16 to 19, at the National Bureau of Standards in Gaithersburg Md.

Sponsored by NBS and the American Association for Crystal Growth, the meeting will provide a forum for exchanging information on all experimental and theoretical aspects of crystal growth and characterization.

Approximately 100 invited and contributed presentations will be given in parallel lecture sessions and in poster sessions.

A special session also will be held to honor the first recipient of the AACG Crystal Growth Award for outstanding contributions to the field of crystal growth. The award is being presented to Sir Charles Frank, OBE, FRS, Professor of Physics, Bristol University, England, who will give a 30 minute address.

Other topics to be emphasized at the conference are low pressure chemical vapor deposition, characterization of defects, materials in space, industrial characterization, fluid flow dynamics, oxides and other crystals for high temperature applications, defects and device characterization, molecular engineering, organic and mineral crystallization, and eutectics, metals, and alloys.

A session of late news items is also being planned. Short abstracts of very recent developments should be sent by July 1 to Dr. Glenn Cullen, RCA Laboratories, Princeton, New Jersey 08540.

The registration fee for the meeting is $70 for members of AACG and $75 for nonmembers. Persons interested in attending should make checks payable to "Crystal Growth Conference" and send to Ronald B. Johnson, B348, Materials Building, National Bureau of Standards, Washington, D.C. 20234.

For information on technical aspects of the conference, write to Dr. Robert L. Parker, B164 Materials Building, National Bureau of Standards, Washington, D.C. 20234 or call Dr. Parker on 301/921-2961.

NCSL AND REGULATORY IMPACT ON METROLOGY MANAGEMENT SYMPOSIUM

The relationship between regulatory agencies and the nation's measurement community is becoming increasingly complex. Effective communication between these two groups is important to the health of metrology. The relationship will be the focus of the 1978 Workshop and Symposium of the National Conference of Standards Laboratories on October 4 to 6 at the National Bureau of Standards in Gaithersburg, Md.

The symposium on "The Regulatory Impact on Metrology Management" will feature two symposium sessions entitled "The Measurement Community as Viewed from the Regulatory Agency" and "Is Universal Laboratory Accreditation Practical?"

Workshop sessions will take up topics of:

- Measurement Assurance Programs
- Legal Metrology at Home and Abroad
- Education and Training of Metrologists
- Accreditation/Enforcement and Monitoring of Laboratories
- Instrument and Measurement Standards Management, and
- Physical and Mechanical Measurements.

The National Conference of Standards Laboratories (NCSL) is a nonprofit organization established in 1961 with the sponsorship of the National Bureau of Standards to promote cooperative efforts towards solving the common problems faced by standards laboratories in their organization and operation. Its membership is open to industrial, commercial, academic, and governmental laboratories concerned with the measurement of physical quantities, the calibration of standards and instruments, and the development of standards of practice. It provides liaison with technical societies, trade associations, and educational institutions interested in these activities.

The registration fee for the 1978 NCSL Workshop and Symposium is $90, but both NCSL members and non-members may preregister at a reduced rate until September 19. Those interested in attending the meeting should contact either of the Symposium co-chairpersons: Dr. Brian Belanger, Room A345, Physics Building, National Bureau of Standards, Washington, D.C. 20234, 301/921-2805, or Mr. Sam L. Davidson, Schlumberger Well, P.O. Box 2175, Houston, TX 77001, 713/928-4570.

BUILDING REGULATORY RESEARCH, INNOVATION CONFERENCE

A building regulatory research conference and administrative procedures workshop will be held for regulatory officials and others from the building community on September 12. The conference, which is cosponsored by the National Bureau of Standards, will coincide with the 11th annual meeting of the National Conference of States on Building Codes and Standards (NCSBCS), Inc., at the Hilton Inn in Annapolis, MD.

Topics to be discussed include:

- Legal, economic, social, political, and technical bases of building regulation
- Evaluation or assessment of management and procedures of regulatory agencies
- Procedures for better communications with architects, engineers, and contractors
- Implementation of energy conservation building standards
- Activities relating to the consensus standards development process
- Studies of planning, policy, or political action aimed at regulatory building construction
- Relation of building regulation to other forms of development control
- Needs of building officials for regulatory research

- Measurement of the economic impact of research on building standards and codes
- Successes and failures with computers and microfilm in building code enforcement and functions
- Development of Codes and Standards for building rehabilitation
- Regulatory implications of new issues and concerns affecting the built environment such as physical security, solar energy, seismic risk, metrication and dimensional coordination, and others.

For further information contact: Patrick W. Cooke, B226 Building Research Building, 301/921-3146.

CONFERENCE CALENDAR

July 13

WORKSHOP ON SUMMER ATTIC VENTILATION AND WHOLE HOUSE FAN VENTILATION, NBS, Gaithersburg, MD; sponsored by NBS; contact: Douglas M. Burch, B122 Building Research Building, 301/921-3513.

July 17-20

FOURTH ANNUAL CONFERENCE OF THE AMERICAN ASSOCIATION FOR CRYSTAL GROWTH, NBS, Gaithersburg, MD; sponsored by NBS and AACG; Robert L. Parker, B164 Materials Building, 301/921-2961.

August 14-16

5TH INTERNATIONAL SYMPOSIUM CONTROLLED RELEASE BIOACTIVE MATERIALS, sponsored by NBS; contact: Frederick Brinckman, A325 Materials Building, 301/921-2847.

September 7-8

SYMPOSIUM ON ATOMIC AND MOLECULAR SCIENCE AND TECHNOLOGY, NBS, Gaithersburg, MD; sponsored by NBS; contact: Stephen Smith, NBS, Boulder, Colo., 303/499-1000, ext. 3631.

September 18-22

CHARACTERIZATION OF HIGH TEMPERATURE GASES, NBS, Gaithersburg, MD; sponsored by NBS, contact: J. Hastie, A307 Materials Building, 301/921-2859.

October 4-6

NATIONAL CONFERENCE OF STANDARDS LABORATORIES, NBS, Gaithersburg, MD; sponsored by NBS and the National Conference of Standards Laboratories; contact: Brian Belanger, A345 Physics Building, 301/921-2805.

October 10-12

3RD ANNUAL CONFERENCE ON MATERIALS FOR COAL CONVERSION AND UTILIZATION, NBS, Gaithersburg, MD; sponsored by NBS and DoE, contact: Samuel Schneider, B308 Materials Building, 301/921-2894.

November 13-15

CERAMIC MACHINING AND SURFACE FINISHING II, NBS, Gaithersburg, MD; sponsored by NBS, Office of Naval Research, Air Force Office of Scientific Research, and the American Ceramic Society; contact: Bernard Hockey, A345 Materials Building, 301/921-2901.

*November 28-30

MECHANICAL FAILURES PREVENTION GROUP, San Antonio, Texas; sponsored by NBS and MFPG; contact: Harry Burnett, B264 Materials Building, 301//921-2813.

*December 4-6

WINTER SIMULATION CONFERENCE, NBS, sponsored by NBS, American Institute of Industrial Engineers; Systems, Man, and Cybernetics Society; Institute of Electrical and Electronic Engineers; Operations Research Society of America, College of Simulation and Gaming, The Institute for Management Sciences and Society for Computer Simulation, The Deauville Hotel, Miami Beach, Fla.; contact: Paul F. Roth, B250 Technology Building, 301/921-3545.

* New Listings

PUBLICATIONS

BUILDINGS DAMAGED IN 1977 ROMANIAN EARTHQUAKE

Observations on the Behavior of Buildings in the Romania Earthquake, Fattal, G., Simiu, E., and Culver, C., Nat. Bur. Stand. (U.S.), Spec. Publ. 490, 168 pages (Sept. 1977) Stock No. 003-003-01841-4, $3.

Details of the extensive building damage caused by the Romanian earthquake of March 1977 are examined in a special publication of the National Bureau of Standards. Information on how buildings perform in such disasters should prove useful to designers and researchers in this country.

Observations on the Behavior of Buildings in the Romania Earthquake of March 4, 1977 describes damage to a wide variety of building types. The report compares U.S. and Romanian seismic design practices, examining how such practices apply to different types of building construction. The study includes observations on buildings which had been designed to resist earthquakes and those which had not. Details of building damage are further covered in 109 photographs.

The report was prepared by NBS engineers in the Center for Building Technology (CBT) who were part of a U.S. government team invited by the Romanian government. The team was sent by the Office of Foreign Disaster Assistance, Agency for International Development (AID). Also on the team were geologists, engineers, and seismologists from the U.S. Geological Survey's Bureau of Reclamation and from the Corps of Engineers.

The trip's immediate purpose was to determine the safety of damaged buildings, major dam sites, and hydroelectric stations. Besides identifying deficiencies in damaged buildings and making recommendations for their strengthening, the investigation also served the purpose of raising questions for future research such as the engineering implications of difference in observed behavior between stiff structures (both precast and cast-in-place concrete) and more flexible building types.

CBT research engineers Charles Culver and George Fattal note that the data collected on earthquake damage provide a basis to assess the relative merits of various building systems in resisting earthquake load and that the trip points to the valuable role of future field investigations in providing the technical data base required for experimental and analytical studies of seismic response in buildings.

The Earthquake Hazards Reduction Act of 1977, passed by Congress in October, indicates rising concern over the vulnerability of U.S. buildings. Seismic experts testified before Congress that last year was the worst in 400 years for earthquake disasters and predicted the United States is a likely candidate for serious earthquakes within 25 years.

CBT's extensive research into earthquake problems for buildings, are reflected in such current NBS research programs as seismic resistant masonry, seismic design of service systems, earthquake-resistant design of buildings, and past earthquake investigations.

TEACHER AIDS

The following materials produced by agencies of the federal government have been examined and recommended by DIMENSIONS/NBS for their potential value as supplements to the classroom or school library.

Productivity and Technological Innovation

Included in this compendium of more than 100 publications and reports on technology and human productivity are items from the National Science Foundation, the Bureau of Labor Statistics, the National Center for Productivity and Quality of Working Life, the Department of Commerce, and various non-federal sources.
Available without charge from:
Publications Distribution
Room 1617
U.S. Department of Commerce
Washington, D.C. 20230

Early Stationary Steam Engines in America: A Study in the Migration of a Technology

This 152-page hardback by Carroll W. Pursell, Jr., is a Smithsonian Institution Press study now available at half-price. Engravings and drawings from colonial times through the nineteenth century help to illuminate the book's informative study of stationary engines, a "less spectacular" subject heretofore eclipsed by the "drama and glamour" of steamboats and railroads.
Order at $4.50 (half-price) from:
Smithsonian Institution Press
P.O. Box 1641
Washington, D.C. 20013

Famous Boundary of Creation

A 28-minute, 16mm sound/color film available on free loan from the National Oceanic and Atmospheric Administration (NOAA). The film deals with the dynamics of the earth's crust as illuminated by French-American studies of the mid-Atlantic ridge. Distinguished by beautiful underwater photography around Iceland, Hawaii, and the Azores, the film was produced in cooperation with the National Science Foundation and Woods Hole Oceanographic Institutions. For free loan (no charge except for return postage), contact:
Motion Picture Service
Department of Commerce-NOAA
12231 Wilkins Avenue
Rockville, MD 20852

The Double-Edge Sword

A 20-minute, 16 mm sound/color film of special interest to college science students, radiologists, x-ray technicians, physicists, and manufacturers of radiation equipment. The film points up the need for fail-safe devices on radiation equipment and explains how responsible use of equipment by knowledgeable people can guard against accidents.
Available on free loan from:
Association Films
600 Grand Avenue
Ridgefield, NJ 07657

For purchase information, contact:
Public Information Division
National Bureau of Standards
Room A640, Administration
Washington, D.C. 20234
Phone: 301/921-3112

Engineering, Product and Information Standards

Devereux, C. W., Marking of Gold Filled and Rolled Gold Plate Articles Other Than Watchcases. (ANSI/VPS PS 67-76), Nat. Bur. Stand. (U.S.), Prod. Stand. 67-76, 6 pages (Aug. 1977) Stock No. 003-003-01813-9, 70 cents.

Devereux, C. W., Marking of Articles Made of Silver in Combination With Gold. (ANSI/VPS PS 68-76), Nat. Bur. Stand. (U.S.), Prod. Stand. 68-76, 6 pages (Sept. 1977) Stock No. 003-003-01854-6, 70 cents.

Devereux, C. W., Marking of Articles Made Wholly or in Part of Platinum. (ANSI/VPS PS 69-76), Nat. Bur. Stand. (U.S.), Prod. Stand. 69-76, 6 pages (Sept. 1977) Stock No. 003-003-01851-1, 70 cents.

Devereux, C. W., Marking of Articles Made of Karat Gold. (ANSI/VPS PS 70-76), Nat. Bur. Stand. (U.S.), Prod. Stand. 70-76, 6 pages (Sept. 1977) Stock No. 003-003-01853-8, 70 cents.

Devereux, C. W., Marking of Jewelry and Novelties of Silver. (ANSI/VPS PS 71-76), Nat. Bur. Stand. (U.S.), Prod. Stand. 71-76, 4 pages (Aug. 1977) Stock No. 003-003-01852-0, 60 cents.

Devereux, C. W., Carbonated Soft Drink Bottles. (ANSI/VPS PS 73-77), Nat. Bur. Stand. (U.S.), 73-77. 11 pages (Nov. 1977) Stock No. 003-003-01877-5, 80 cents.

Walkowicz, J., Dictionary for Information Processing, Nat. Bur. Stand. (U.S.), Fed. Info. Process. Stand. (U.S.), Fed. Info. Process. Stand. Publ. (FIPS PUB) 11-1, 4 pages (Sept. 1977).

Wood, J. F., Ed., Guidelines for Benchmarking ADP Systems in the Competitive Procurement Environment, Nat. Bur. Stand. (U.S.), Fed. Info. Process. Stand. Publ. (FIPS PUB) 42-1, 27 pages (May 1977).

Fluids: Liquids, Gases and Plasmas

Irwin, L. K., Ed., Flow Measurement in Open Channels and Closed Conduits. Proceedings of the Symposium on Flow Measurement in Open Channels and Closed Conduits held at the National Bureau of Standards in Gaithersburg, MD on Feb. 23-25, 1977, Nat. Bur. Stand. (U.S.), Spec. Publ. 484, Vol. 1, 479 pages, Vol. 2, 490 pages (Oct. 1977) Stock No. 003-003-01845-7, $12.25 per 2-part set.

Instrumentation and Experimental Methods

Lind, M. A., and Fowler, J. B., Four Versatile MIDAS Compatible Modules, Nat. Bur. Stand. (U.S.), Tech. Note 958, 34 pages (Nov. 1977) Stock No. 003-003-01866-0, $1.40.

Measurement Science and Technology Physical Standards and Fundamental Constants

The International System of Units (SI), (Supersedes NBS Special Publication 330, 1974 Edition), Nat. Bur. Stand. (U.S.), Spec. Publ. 330, 46 pages (Aug. 1977) Stock No. 003-003-01784-1, $1.60.

Metrology: Physical Measurements

Nicodemus, F. E., Richmond, J. C., Hsia, J. J., Ginsberg, I. W., and Limperis, T., Geometrical Considerations and Nomenclature for Reflectance, Nat. Bur. Stand. (U.S.), Monogr. 160, 36 pages (Aug. 1977) Stock No. 003-003-01793-0, $2.

Varner, R. N., FORTRAN Program to Determine Length of Gage Blocks Using Single Wavelength Interferometry, Nat. Bur. Stand. (U.S.), Tech. 956, 55 pages (Sept. 1977) Stock No. 003-003-01840-6, $2.

Other Subjects of General Interest

Brown, B. F., Burnett, H. C., Chase, W. T., Goodway, M., Kruger, J., and Pourbaix, M., Corrosion and Metal Artifacts—A Dialogue Between Conservators and Archaeologists and Corrosion Scientists, Nat. Bur. Stand. (U.S.), Spec. Publ. 479, 252 pages (July 1977) Stock No. 003-003-01826-1, $3.75.

Jespersen, J., and Fitz-Randolph, J., From Sundials to Atomic Clocks—Understanding Time and Frequency, Nat. Bur. Stand. (U.S.), Mongr. 155, 177 pages (Dec. 1977) Stock No. 003-003-01650-1, $4.

Saltman, R. G., Computer Science and Technology: Copyright in Computer-Readable Works: Policy Impacts of Technological Change, Nat. Bur. Stand. (U.S.), Spec. Publ. 500-17, 267 pages (Oct. 1977) Stock No. 003-003-01843-1, $4.

Tascher, J. M., A Survey of the National Bureau Metric Speakers Bureau, Nat. Bur. Stand. (U.S.), Tech. Note 960, 56 pages (Nov. 1977) Stock No. 003-003-01860-1, $2.30.

Publications stated here may be purchased at the listed price from the U.S. Government Printing Office, Washington, D.C. 20402 (foreign: add 25%). Microfiche copies are available from the National Technical Information Service, Springfield, VA 22161. For more complete periodic listings of all scientific papers and articles produced by NBS staff, write: Editor, Publications Newsletter, Administration Building, National Bureau of Standards, Washington, D.C. 20234.

Subscription Order Form

ENTER MY SUBSCRIPTION TO DIMENSIONS/NBS (C13.13) at $12.50. Add $3.15 for foreign mailing. No additional postage is required for mailing within the United States or its possessions.

Send subscription to:

NAME—FIRST, LAST

COMPANY NAME OR ADDITIONAL ADDRESS LINE

STREET ADDRESS

CITY | STATE | ZIP CODE

PLEASE PRINT

☐ Remittance enclosed (make checks payable to Superintendent of Documents)

☐ Charge to my Deposit Account No.

MAIL ORDER FORM TO:

Superintendent of Documents
Government Printing Office
Washington, D.C. 20402

NEWS BRIEFS

DILLON NAMED DEPUTY DIRECTOR. Dr. Ernest Ambler, Director of the National Bureau of Standards, has selected Dr. Thomas A. Dillon to be the new NBS Deputy Director. He was most recently acting director of the Advanced Systems and Materials Production Division of the Department of Energy. Graduated in 1966 from Harvard College with a major in chemistry and physics, Dillon received a Ph.D. in chemical physics from the University of Colorado in 1969. Dillon was employed at NBS from 1969 to 1976 as both research scientist and administrator.

SCIENCE ON ITS WAY TO WORK. The activities of the National Bureau of Standards during the fiscal year ending September 30, 1977, are described in a new NBS Special Publication. Particular attention is paid to the effects of these programs on industry, government, and the international scene, as well as on our everyday lives. Emphasis is also placed on the transfer mechanisms--how technology gets from here to there. Order Science on Its Way to Work from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402, Stock No. 003-003-01943-7, for $1.60.

DRUG SUBSTITUTION LIST. The New York State Department of Health has just published its list of generic drugs that may be substituted for equivalent but more expensive brand name products. Until recently, the list was available only from Food and Drug Administration's Freedom of Information Office for $13.60. Now it can be purchased for $1 by writing to Health Education Service, P.O. Box 7126, Albany, NY 12224. Ask for Safe, Effective and Therapeutically Equivalent Prescription Drugs.

CONFUSED ABOUT INSULATION? Your purchasing choice may be a little easier in the near future if manufacturers voluntarily start using a new label proposed by the Department of Commerce. Designed to give consumers understandable information at the point of sale, such a label on each package would provide data on the insulation's thermal resistance fire safety rating, possible corrosiveness, area of coverage, recommended application, and other factors. Commerce is now getting public reaction to its proposal.

ANNUAL WEIGHTS AND MEASURES CONFERENCE. "Changing Dimensions and Directions in Measurement Assurance" is this year's theme at the 63rd National Conference on Weights and Measures sponsored by NBS. An assortment of theme-related topics are scheduled. The conference runs from July 9 through 14 at the Shoreham Americana Hotel in Washington, D.C. For further information contact Harold F. Wollin, A209 Metrology Building, NBS, Washington, D.C. 20234.

NEXT MONTH IN

DIMENSIONS NBS

The Harmer House Convalescent Home fire and other fatal blazes similar to it convinced fire researchers that the old assumption that floor coverings do not play a significant role in the spread of fire was a myth. Read about the behavior of floor surfaces in corridors during fire in the next issue of DIMENSIONS/NBS.

U.S. DEPARTMENT OF COMMERCE
Juanita M. Kreps, Secretary
Sidney Harman, Under Secretary

Jordan J. Baruch, Assistant Secretary for Science and Technology

NATIONAL BUREAU OF STANDARDS
Ernest Ambler, Director

Prepared by the Public Information Division
Washington, D.C. 20234

Richard S. Franzen, Chief

Madeleine Jacobs, Chief, Media Liaison and General Publications

Juli Kelley, Editor

Justine A. Williams, Editorial Assistant

Skip Wenner, Visual Editor
(Commerce Department)

PHOTO CREDITS

Mark Helfer: Cover II, pages 3 and 5 top left and center, and 12-17.

Hank Glittenberg: Page 5 top right.

Steve Henneman: Page 16.

The Commerce Department's National Bureau of Standards was established by Congress in 1901 to advance the Nation's science and technology and to promote their application for public benefit. NBS research projects and technical services are carried out by the National Measurement Laboratory, the National Engineering Laboratory, and the Institute for Computer Sciences and Technology. Manufacturing, commerce, science, government, and education are principal beneficiaries of NBS work in the fields of scientific research, test method development, and standards writing. DIMENSIONS/NBS describes the work of NBS and related issues and activities in areas of national concern such as energy conservation, fire safety, computer applications, materials utilization, and consumer product safety and performance. The views expressed by authors do not necessarily reflect policy of the National Bureau of Standards or the Department of Commerce.

For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402. Annual subscription: Domestic, $12.50, foreign, $15.65, single copy, $1.05. The Secretary of Commerce has determined that the publication of this periodical is necessary in the transaction of the public business required by law of this Department. Use of funds for printing this periodical has been approved by the Director of the Office of Management and Budget through June 30, 1981.

AN EQUAL OPPORTUNITY EMPLOYER

U.S. DEPARTMENT OF COMMERCE
National Bureau of Standards
Washington, D.C. 20234

OFFICIAL BUSINESS
Penalty for Private Use, $300
RETURN POSTAGE GUARANTEED

POSTAGE AND FEES PAID
U.S. DEPARTMENT OF COMMERCE
COM-215

U.S.MAIL

CONTROLLED CIRCULATION RATE

DNBS SERIA300SEISSDUE008R 1
SERIALS PROCESSING
UNIVERSITY MICROFILMS INTL
300 N ZEEB RD
ANN ARBOR MI 48106